THE
POPULAR SCIENCE
MONTHLY.

MAY, 1913

A PROBLEM IN EVOLUTION

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I. The Scope of Morphology

WHEN evolution became the accepted doctrine of the natural sciences, it was incumbent on the zoologists to construct a genealogy, or phylogeny, of the animal kingdom, one that would reveal the great highways of evolution and disclose the historic sequence in the rise of new kinds of animals, from the dawn of life to the present time, from the protozoon to man.

A complete genealogy of the animal kingdom, or even one as nearly complete as the biologist may reasonably hope to produce, would be of great value. It would represent the measure of our evidence that animal evolution had taken place. It would constitute the framework of the entire science of zoology, for at the root of every problem in anatomy, embryology, physiology and paleontology is the question of origin. It would be a moving historic picture of evolution, exhibiting the successive stages of the process and the creative value of the accompanying conditions.

The experimental methods of the laboratory and breeding-pen may measure the pliability of life under the momentary stress of artificial conditions, but only the phylogenetic history of large groups of animals, extending over immeasurably long periods of time, under various environments, can indicate the manner in which evolution actually did take place; whether it was slow or rapid, uniformly progressive or spasmodic, direct or tortuous; whether it drifted with the ebb and flow of circumstance, or opportunely threaded its way through an unyielding, but slowly changing, environment. And the manner in which

evolution has taken place is the only thing that can indicate the creative value of the accompanying conditions; whether or no, or to what extent, evolution has been the product of external conditions, of natural selection, or of the fortuitous shuffling of "hereditary units"; or whether, after giving due credit to these agents, we must go still deeper and look for the primary creative factors in a universal, persistent power of growth, and in an internal, automatic adjustment of part to part and part to the whole, which go their ways in spite of the fluctuating influences of heredity, selection and external environment, moving with an increasing momentum of their own along definite paths toward definite ends that are predetermined solely by the nature of organizable materials.

In my judgment, the answer to these problems must come, if at all, from morphology, treated as the formal expression of the dynamics of organic growth, and from the history of its progress as portrayed by the embryology of the individual and the phylogeny of the race. The answer should tell us whether biology shall serve merely to record the phenomena of life, or whether, within its own sphere, it may reasonably hope to attain in some measure the dignity of prophet and master.

II. Missing Links in the Genealogy of the Animal Kingdom

To the layman, the most serious defect in our phylogenetic record is the absence of a connecting link between man and the apes. To the morphologist, dealing with broader aspects of the problem, it is the absence of a whole series of connecting links between the vertebrates and the invertebrates.

The evolution of the vertebrates has extended over many millions of years, from at least the beginning of the Devonian period to the present moment; but during all that time no change in the general plan of their structure has taken place. The vertebrates form an essentially continuous, united group, for the differences between the most widely separated members, as, for example, a fish and a human being, are differences in degree, not in kind; differences in the details of structure, and in the relative location and size of organs and parts of organs, or in the measure of their functions; none whatever in their serial location, in their fundamental structure, or in their mode of growth. Every important part, for example, of the digestive, excretory and reproductive systems, and of the skull, nose, eye, ear, heart and brain of a fish is readily recognized by the trained anatomist in the corresponding organs of man.

It is this broad uniformity in fundamental structure, varied by a continuous series of transitions in organic details, and the historic record of their progress by paleontology, that is the chief measure of blood relationship and community of descent.

The first vertebrates to make their appearance on the face of the earth were fishes. They are still wonderfully well preserved as fossils in the rocks of the Devonian period; and it is perfectly clear that, when alive, they were practically identical in structure with certain fishes now living. But we have no records of true fishes from an earlier period; from this point downwards into the abyss of time, without warning or apparent reason, the vertebrates drop from the records, although the records themselves remain, and they contain, both after that period and for an immeasurably long time previous to it, a full, even a detailed, account of nearly every known group of invertebrates. Why do the vertebrates disappear at this point? Where did they come from? What kind of invertebrates were their ancestors? How did the anatomical structures peculiar to all vertebrates originate? Heretofore no one has been able to give even an approximately satisfactory answer to these questions. Here indeed is a great gap in the evolution of the animal kingdom. It is not merely one link that is missing; the whole middle section, perhaps two thirds of the entire animal kingdom, is either absent, or, if present, it has not been recognized and properly located. As there is no apparent resemblance between the structural plan of any known invertebrate and that of a vertebrate, there is no way of uniting the higher animals with the lower; no way of deciding what was the great trunk line of evolution.

This is a serious defect in the very foundations of the biological sciences. While it remains we are compelled to admit that, with all our boasted schemes of classification according to genetic relationships, the whole class of vertebrates hangs in mid-air over an unknown and apparently inaccessible abyss; that we are totally ignorant of the great creative period in the evolution of the highest type of animals; that we know nothing of the way in which the fundamental structural features of man arose; that we have no basis for the interpretation of the early stages of his embryonic development; and no clue to the initial significance of a single one of his characteristic organs, such as the mouth, notochord, skeleton, lungs, jaws, appendages, heart, thymus, thyroids, pituitary body, pineal gland, sense organs and brain!

III. The Origin of Vertebrates Abandoned as a Hopeless Problem

During the generation following the appearance of Darwin's "Origin of Species," many attempts were made to bridge this great gap in our knowledge of evolution. The best known theories were defended by the most distinguished zoologists of their time; but they were, after all, mere suggestions, and their authors were compelled to unite the nearest probable extremes by long arrays of purely imaginary animals.

Most of the theories were mutually exclusive; none of them were based on detailed comparisons of several systems of organs; and none of them threw any light on vertebrate anatomy, or afforded even an approximate solution of the real problem.

The vital spark in these theories vanished long ago, but certain basic postulates in them have slowly petrified into the semblance of established facts and have introduced into morphology many false ideas, and a system of nomenclature that implies a knowledge we by no means possess. Many a zoologist, proud of his adherence to sound zoological principles, accepts these familiar terms as evidence that the things so named are really what the names imply, as, for example, the terms dorsal and ventral, right and left, gastrula, archenteron, blastopore and cœlomic pouches. The same subtle transformation of theory into fact is shown by the perpetuation of the view that the notochord is made of endoderm because it arises from the walls of the "archenteron"; and by the one that the primitive streak represents the closed lips of an "Uhrmund."

When real progress along the old lines ceased, the problem came to be regarded as hopeless, largely because it was assumed that the ancestors of the vertebrates were small, soft-bodied animals, unlikely to be preserved as fossils. The "practical" biologist then turned his attention to cytology, experimental evolution and genetics, and the study of morphology and phylogeny became almost as discreditable an occupation, especially in the eyes of the new school of biologists in this country, as the study of metaphysics, or the description of new species.

During this long search for the ancestors of the vertebrates, the arthropods (insects, crustacea and arachnids), the largest and most highly organized class of invertebrates were altogether excluded, with astonishingly aggressive unanimity, from their due consideration. It is difficult to understand this impenetrable state of mind, for it did not appear to be based on any known facts, or upon any positive evidence whatever. It was apparently due to a widespread conviction that the general trend of evolution in the arthropods did not lead toward the vertebrates, that the arthropods themselves were too highly specialized to give rise to a new type, and to the fact that the hue and cry of the annelid theory was leading the chase in another direction.

In view of this situation, it may be readily understood that another attempt to connect the genealogy of the vertebrate stock with that of the invertebrates will now have to contend with a widespread indifference born of repeated failures; with interests already diverted into other channels; and with that first, unreasoning hostility that is the protective attitude of the mind toward any strange idea that threatens to steal away our cherished convictions.

IV. First Clues to a New Solution

As long ago as 1889, while working on the development of the eyes of arthropods, the author discovered that the forebrain of the embryo scorpion is gradually covered by an overgrowing fold of skin that converts the brain into a hollow vesicle. During this process, one or two pairs of eyes are transferred from the outer surface of the head to the blind end of a median tube that projects from the membranous roof of the brain.

The details of the whole process by which the eyes were transferred from the outer surface of the head to the inside of the brain were unique in the invertebrates, and so similar to what takes in the formation of the rudimentary pineal eye of vertebrates, that it clearly pointed to some intimate genetic relation between the two groups.

To test what at first sight appeared to be so improbable, a careful study of the anatomy and development of several types of arachnids was made, and, much to our astonishment, it was found that the brain of the arachnids resembled that of the vertebrates in its general shape, in its subdivision into several regions, in the general nature of the functions performed by these regions, and in the character of their appropriate nerves, ganglia and sense organs; that the arachnids possessed skeletal structures comparable, respectively, with the dermal bones, cranium, gill-bars and notochord of vertebrates; and finally it was seen that the development of the embryo and the formation of the germ layers in the arachnids, not only harmonized with, but illuminated the corresponding conditions in the vertebrates.[1]

It was evident that in their fundamental structure the arachnids resembled the vertebrates more than did any other invertebrates; and they resembled them in so many different ways that it became more and more improbable that all these resemblances could be mere coincidences, or could be reasonably accounted for as duplications of structure due to similar functions, or to environment, or to any conceivable cause other than community of origin. Nevertheless, it was hardly possible that the vertebrates came from modern air-breathing scorpions, or spiders, for the lowest vertebrates undoubtedly came from marine animals.

But the modern land arachnids are descendants of a large group of very ancient marine arachnids, the trilobites and merostomata, or giant sea-scorpions, which flourished in the early Cambrian and Ordovician periods, long before any vertebrates were known to exist. They were also found, although in rapidly diminishing numbers, in the two

[1] For a fuller description of these conditions, too technical to be repeated here, see "The Evolution of the Vertebrates and their Kin," by W. Patten. P. Blakiston & Co., Philadelphia.

following periods, and often in the very same deposits in which the first vertebrates are found. Moreover, during the Silurian and Devonian periods, and living in intimate association with the declining marine arachnids and the earliest vertebrates, there was known to exist a peculiar class of animals called the Ostracoderms. Very little was known about them, for their remains were fragmentary and their meaning doubtful. Some of the species were regarded as vertebrates, others as invertebrates, and some of them showed a superficial resemblance to the sea-scorpions, as had been noticed by the older anatomists (Fig. 2). But after considerable discussion and a thorough reexamination of the available material, mainly by Huxley and Lankester, it was definitely decided that they were fishes, probably a very specialized kind, of no great importance morphologically. They were then forgotten, or at any rate their very existence remained quite unknown to many zoologists.

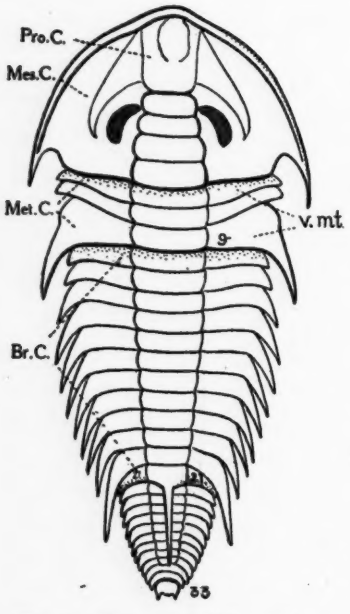

FIG. 1. TRILOBITE (*Mesonacis vermontana* Hall). Lower Cambrian. One of the marine Arachnids.

In view of their unfishlike appearance and their great antiquity, it is astonishing that no one suggested they might be very primitive vertebrates, or perhaps an even more remote ancestral stock, until the author did so in his first paper on "The Origin of Vertebrates."[2]

This oversight was largely due to the fact that, at that time, zoologists firmly believed that the most primitive vertebrates were like sharks, or like *Amphioxus;* that is, animals that had little or no skeleton, while the Ostracoderms were encased in an extraordinary dermal armor, in some respects quite like that of a trilobite or sea-scorpion. Something appeared to be wrong, either in the facts or in the conclusions. Could it be possible that, after all, the ostracoderms were not true fishes, but a new class of animals, a class intermediate between the fishes and the sea-scorpions? In some respects they looked as much like the one as the other, and they appeared at the right time historically to be the long-sought-for missing links between vertebrates and invertebrates. If they really were transition forms, that would fully account for the resemblance between the modern arachnids and

[2] *Q. J. Mic. Sc.*, Vol. 31, 1890.

the vertebrates, for in that case both would be derived from the same stock.

Here then, contrary to all our preconceived ideas, was a new solution of an old and very important problem, probably the most important one before the morphologist since Darwin's time. It was evident that this solution of it, if sustained, would lead to more radical changes in the classification of the animal kingdom than any that have been made since the time of Cuvier and Lamarck. Stated concisely, it was as follows: At some time toward the close of the Cambrian period the sea-scorpions probably gave rise to the ostracoderms, and the latter,

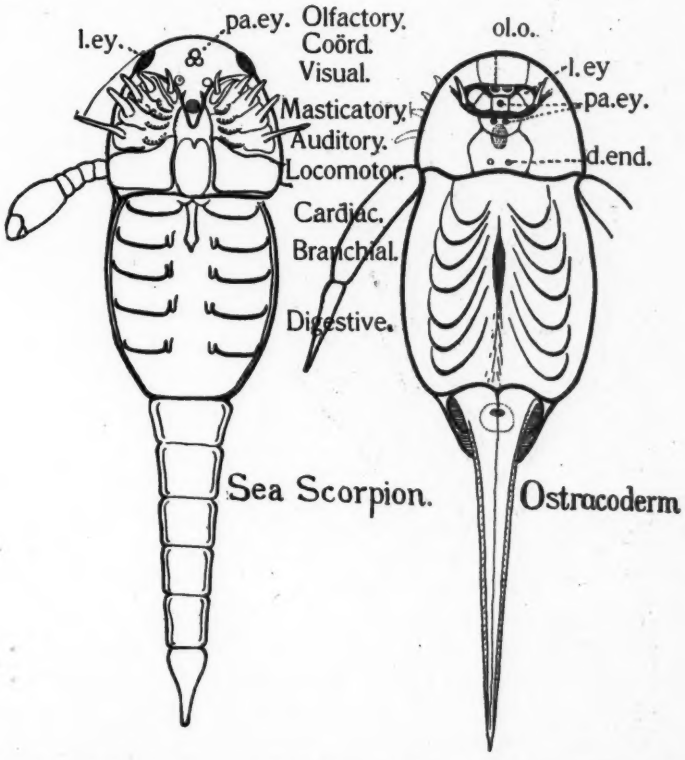

FIG. 2. SEMI-DIAGRAMMATIC FIGURES OF A SEA SCORPION (EURYPTERID) AND AN OSTRACODERM (*Bothriolepis*), showing the sequence in the location of the important functions, and the subdivisions of the body corresponding to the subdivisions of the head and brain in the higher vertebrates.

during the Silurian, to the fishes, or first true vertebrates (Fig. 3). This was an entirely new interpretation in phylogeny, but it was not inherently improbable, or contrary to any established facts; indeed, the first demands of the theory were in full accord with the known facts of anatomy, embryology and paleontology. Let us state it again in this way: In their fundamental structure, living arachnids resemble

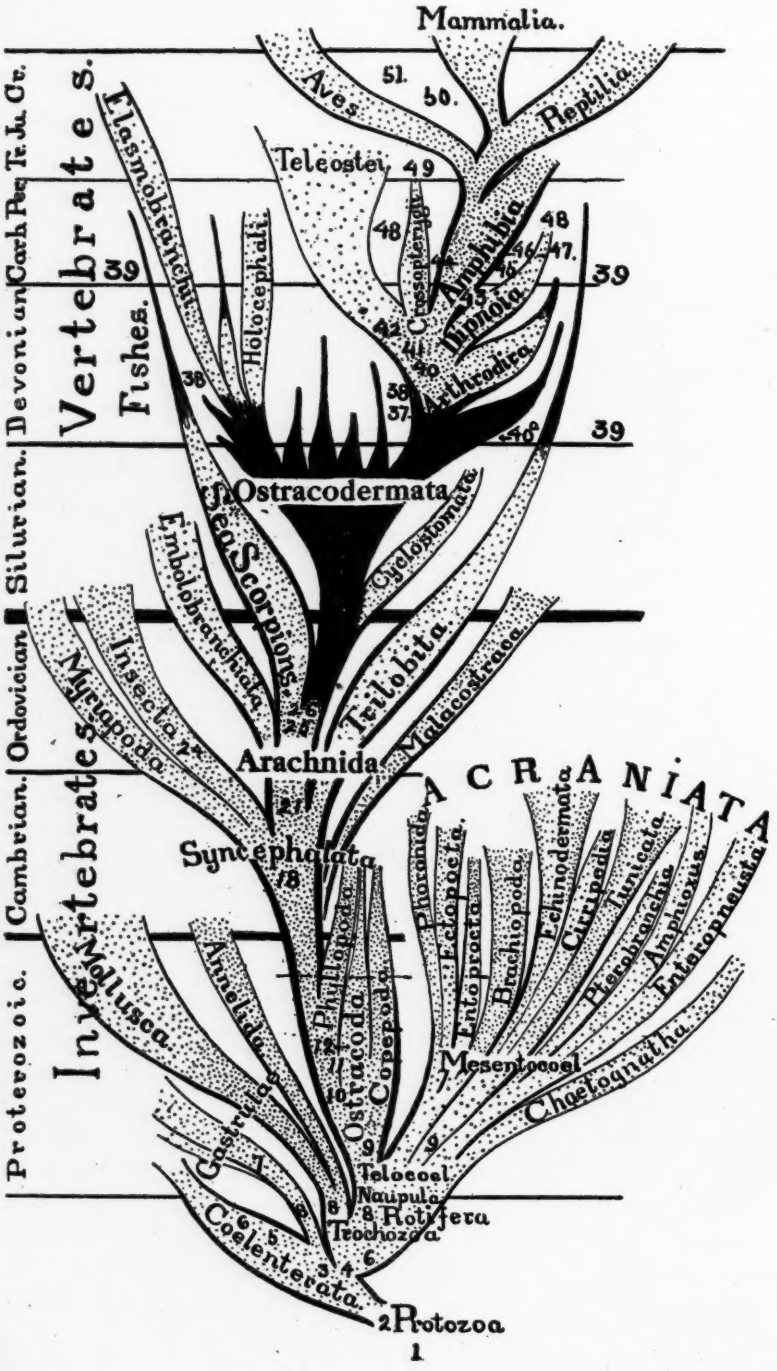

FIG. 3. GENEALOGICAL TREE OF THE ANIMAL KINGDOM, showing the probable genetic relations of the main phyla. The Ostracoderms, the connecting links between the vertebrates and invertebrates, are in solid black.

primitive vertebrates. The ancestral arachnids were marine forms, present in the oldest records we have; they flourished in the Cambrian, and were the highest type of animals in existence at that time. The ostracoderms flourished in the following, or Silurian, period and were the highest type of their time. They had some points in common with their predecessors, the marine arachnids, and also with the true fishes that appeared in the next, or Devonian, period, and which were likewise the highest type of their time. The inference is obvious, that the marine arachnids, the ostracoderms, and the fishes, represent three successive stages in the evolution of the animal kingdom, just as in the later periods the fishes, amphibia and mammals represent successive stages in the evolution of the vertebrates. If this inference is correct, then the whole creative period in the evolution of the vertebrate stock should become an open book, because the materials, both living and fossil, with which one can unravel the evolution of the arachnids, are apparently abundant and accessible.

This situation demanded careful investigation, for the issues at stake were very great. In 1889, when this problem for the first time assumed definite shape in my mind, it was apparently impossible to obtain well-preserved ostracoderms in this country, nor did the known remains in any country appear likely to yield more than the superficial details of their anatomy.

We were thus compelled to wait on opportunity, meantime, during the next ten or eleven years, giving our attention to the anatomy and embryology of living arachnids and the lower vertebrates, convinced that a careful study along these lines would ultimately yield definite evidence, one way or the other. The results fully justified this conclusion, for the longer this problem was studied, the more convincingly did it appear that the differences between these two great divisions of the animal kingdom were largely superficial and could be legitimately explained. The resemblances were fundamental; they were found in unexpected places, in independent systems of organs, and they ran through successive stages in the growth of those organs. It was clear that no other group of invertebrates resembled the vertebrates in such a variety of ways, or to the same extent, as did the arachnids; and no one has claimed that the main facts upon which these resemblances were based are not substantially as I have stated them to be.

We had demonstrated, therefore, that the marine arachnids are to be regarded as the most probable ancestors of the vertebrate stock.

V. The Ostracoderms

But in spite of all that, there still remained a wide gap between the arachnids and the vertebrates, and to bridge that gap we had to find

FIG. 4. A RESTORATION OF *Cephalaspis*, based mainly on a species from the lower Old Red Sandstone of Scotland. Ostracoderm.

some animals that were intermediate in structure between them, and which made their appearance at some time not later than the Silurian period. The ostracoderms were the only ones known to science in any way likely to fulfil these requirements; it was, therefore, of the utmost importance to learn something more about these mysterious, extinct animals, for they appeared to contain the solution of the whole problem.

The first opportunity to test this side of the problem came in 1900–01, with a half-year's leave of absence from college duties. The prospects of success, however, were very small, especially for one trained as a laboratory morphologist and embryologist, and without experience in field geology or in paleontology. There was a bare chance that a reexamination from another point of view of the material preserved in the British Museum and other institutions, and that had already been studied by Huxley, Lankester, Traquair, Woodward and others, might reveal some suggestive details overlooked by these past masters of the subject. Failing that, it would be necessary to go into the field and dig up new material that, to serve our purpose, would have to be more perfectly preserved than any that had, by chance, been found in the preceding three quarters of a century. It was not a promising outlook, but the opportunity was gladly accepted.

We first visited the great museums of England and Scotland, and the localities where, in the early thirties, Hugh Miller unearthed the first specimens of these animals known to science, which he afterward described with such remarkable literary skill and enthusiasm in his "Footprints of the Creator," and in the "Old Red Sandstone."

But the best material available in England and Scotland was provokingly incomplete in regard to the very structures it was most important for us to know about. However, some unexpected and suggestive details were found that greatly added to the already keen excitement of the search (Fig. 4).

It was then decided to visit the famous Silurian quarries on the Island of Oesel, in the Baltic Sea, and the museums of St. Petersburg and Moscow, where many of the Oesel fossils were preserved.

The representatives of the ostracoderms (*Trematapis*) found in the Silurian rocks of the Island of Oesel are only about three inches long. But in spite of their small size, they are, in some respects, admirably preserved in a soft, fine-grained limestone; and they promised to yield important data. In fact, the specimens that were obtained there showed the presence of jointed appendages and shell-covered, stalk-like eyes. These structures were unlike those of true fishes and more like what one would expect to find in some free-swimming sea-scorpion. In that respect the results were highly satisfactory, and added still more evidence in favor of our first supposition (Fig. 5).

But on the whole, we felt that the results of our European expedition were incomplete, because nothing like a full account of the gross anatomy of any one species of ostracoderms was obtained. The organs about the mouth and the location of the principal viscera and of the nervous system were entirely unknown; and it was quite essential to obtain evidence on these points, because it had become increasingly clear that this strange class of animals could not be safely interpreted in terms of either vertebrate or invertebrate anatomy.

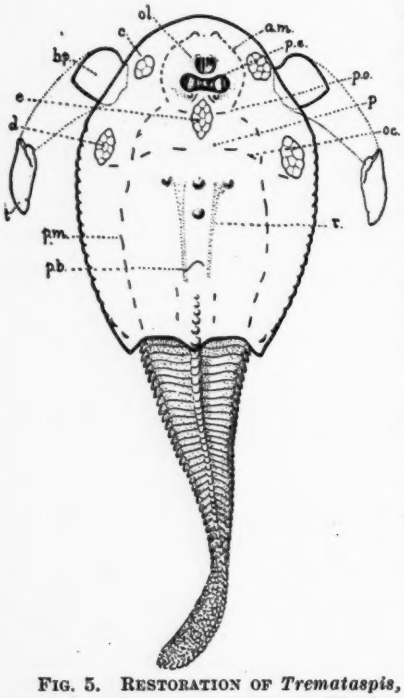

FIG. 5. RESTORATION OF *Trematapsis*, an Ostracoderm from the upper Silurian rocks of the Island of Oesel, Baltic Sea.

On my return to America it was decided to make an attack on a younger branch of the ostracoderms; one that was known to occur in the Devonian rocks of the Bay of Chaleur in Canada.

Four summers were spent in this locality, in search of specimens well enough preserved to be used for anatomical study. Fragments, or in some cases nearly the whole head, could be readily found on the beach at low tide, or by splitting open the disc-shaped nodules that had been washed from the adjacent cliff. But these specimens were generally crushed out of shape, or were so badly weatherbeaten and worn that they were of little value. We hoped to find in the cliff, which extended along the water front for several miles, unweathered specimens that would show not only the whole head, but the rest of the body, the nature of which at that time was entirely unknown. We accordingly examined with great care the face of the cliff as far as it was accessible; and many tons of rock were dug out of it and split open in order to locate the particular beds that contained the fossils; but the latter appeared to be very irregularly distributed, for we did not succeed in finding a single specimen in that way.

At last we found, close to the foot of the cliffs, a large piece of rock that contained several fossils of the kind we were looking for. It could not have been carried there either by the waves or by drifting ice, for evidently it had fallen quite recently from the rocks above. It did not take long to locate, about twenty-five feet above this fragment, the beds

from which it came. To reach them, a path had to be cut into the face of the cliff, and the rocks overlying the beds removed with dynamite, or with pick and bar; an operation not without some danger from rocks that from time to time fell from the crumbling cliffs above. Twice, without warning, fragments weighing some fifty pounds each fell at our feet, knocking the tools from our hands; and where they came from there were other loose ones, at least ten times as large. Our attention was reluctantly, but impartially, divided between the maintenance of a precarious footing on the face of the sweltering cliff, the threatening rocks overhead, and the treasures at our feet.

The bed was not extensive, but it proved to be literally teeming with these extraordinary animals (*Bothriolepis canadensis*), and by good fortune they were in a remarkably complete and instructive state of preservation; more so, perhaps, than any other fossils found heretofore (Fig. 6).

The bed had apparently formed the bottom of a shallow, brackish water-pool in which fern-like water plants had been growing, and where many millions of years ago, with the rise and fall of the tides, these specimens had been trapped, together with other species of ostracoderms and several kinds of true fishes.

The soft mud on the bottom of the pool was now turned into a fine-grained, sandy limestone, and in it the fossilized animals were preserved in the very attitudes they had assumed when they ceased to struggle out of the enclosure. One, in its death agony, had plunged into the mud with sufficient force to remain there, head down, in a vertical position. Others were arranged in horizontal series, uniformly headed in a northeast direction. Their heads were turned against a gentle current of water, as was shown by the fact that the tops of all the ferns were pointed in nearly the opposite direction.

Many of these specimens were so well preserved that the shape of the whole body, and many details on its external surface, could be readily observed; the general character and location of the principal sense organs, jaws, gills, stomach, anus and genital openings ascertained; and the neural and hæmal surfaces identified. It was also possible to determine, beyond reasonable doubt, the mode of locomotion, the mode of feeding and the nature of the food.

Of course this message from a remote past was not off-hand legible. After the scores of specimens were safely housed in the laboratory, it required nearly three years to chisel and scratch and brush away the rocky matrix in which they were imbedded, and after that many specimens had to be cut into serial sections with a diamond saw, and the sections polished and varnished to show the arrangement of the internal organs.

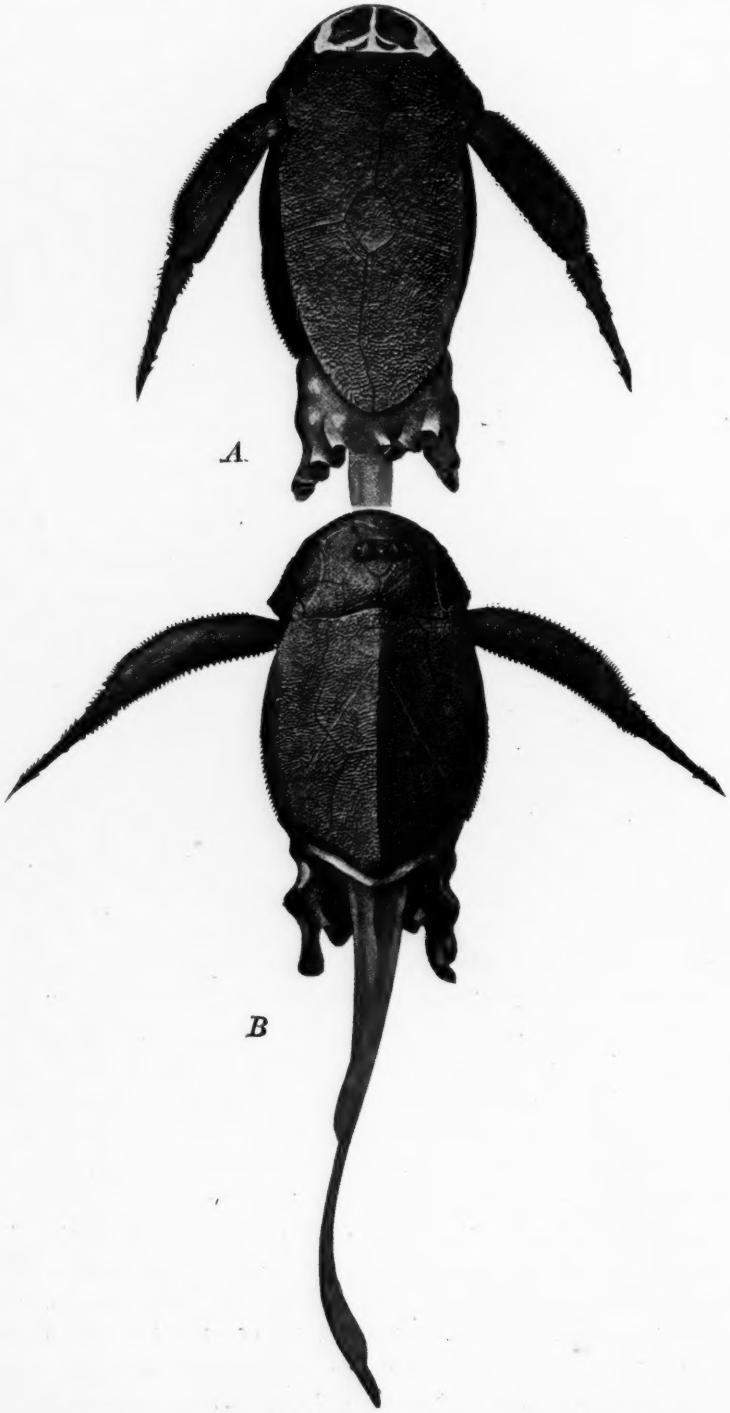

FIG. 6. RESTORATION OF *Bothriolepis Canadensis;* an Ostracoderm from the Upper Devonian of the Bay of Chaleur, Province of Quebec, Canada.

But "the labor we delight in physics pain," and patient labor is but the measure of hoped-for rewards. In this case the realization exceeded all reasonable expectations; for, if he may be counted fortunate who, by chance, finds some soothsaying relic of early life, how much more than fortunate, how exceedingly blest, is the naturalist who is permitted to lift with his own hands from some ancient storehouse of the earth a long-sought-for treasure, and to awake in it, with the chisel's kiss a spirit from the childhood era of the world!

VI. A Critical Period in Organic Evolution

The net result of this fortunate find was to show that the ostracoderms, as had been predicted, were neither vertebrates nor invertebrates, but a class intermediate between the two. They were, in fact, the real missing links in the animal kingdom. The posterior part of the body was membranous and decidedly fish-like in shape; but the contour of the whole animal, especially the head, the nature of the appendages, the eyes and the mode of locomotion, were more like those of the marine scorpions. The gill, or atrial, chamber, and the structure of the dermal skeleton were intermediate in character (Figs. 2 and 6).

But the most important features of all were the long sought for mouth parts, or jaws. They were paired, consisting of four separate jaws, which in chewing, or biting, moved to and from the median line, like the jaws of all known arthropods (Fig. 6, *A*). They were not unpaired arches moving forward and backward, as they do in all true vertebrates.

To realize the significance of this fact, it must be understood that one of the greatest differences between a vertebrate and an arachnid, or arthropod, is the position and character of the jaws and mouth. In all arthropods and arachnids, the mouth and jaws are primarily located on the same side of the body as the nervous system; food enters the alimentary canal by a passage-way in the floor of the brain; and there may be several pairs of jaw-like legs, which, in chewing, work in a lateral direction to and from the median line. In the adult vertebrates the jaws lie on the opposite side of the body from that on which the brain and nerve cord are located; the food that enters the mouth passes directly into the alimentary canal without going through a passage-way in the floor of the brain; and the jaws are two unpaired arches that work against each other in a forward and backward direction (Fig. 7, *A* and *B*).

It is evident that either we are not dealing with the same things in the two classes, or that there has been some change in their relative locations. As a matter of fact, it is part one and part the other; for we have been able to demonstrate: (1) That the nervous system of the

arachnids is identical with that of the vertebrates, and lies on the same side of the body. It affords us the fixed base line of comparison. (2) That in embryo vertebrates there are at least three pairs of primitive jaws that arise from the neural surface; they are gradually shifted from their old position to a new one on the opposite side of the head.

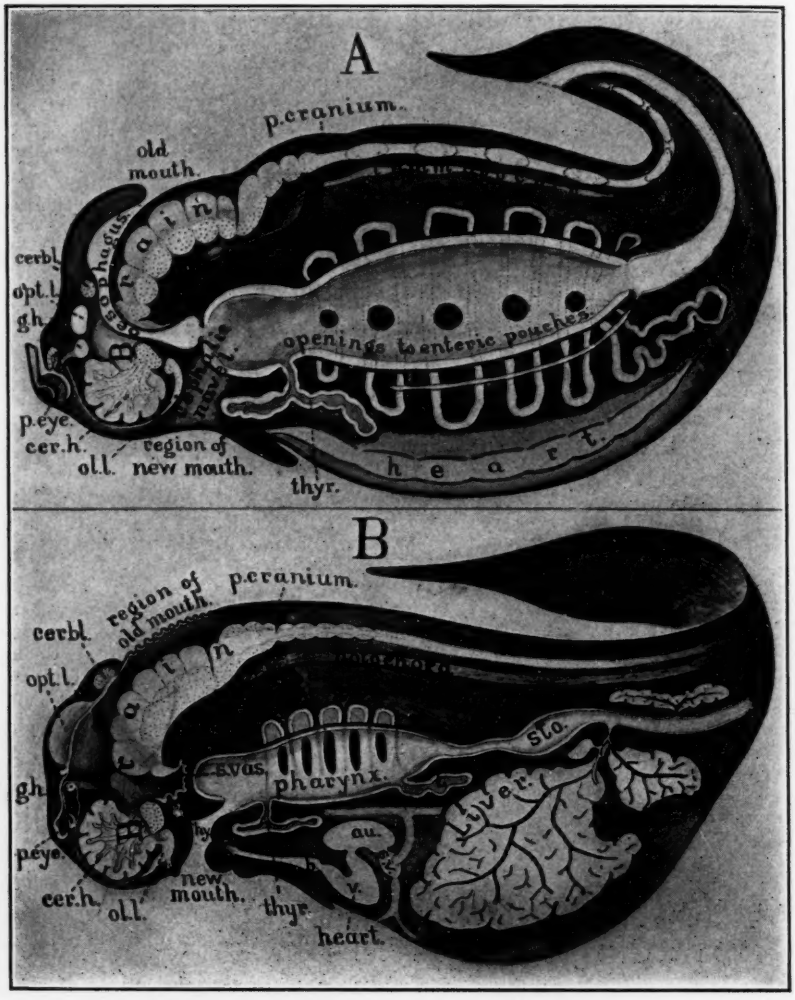

FIG. 7. SEMI-DIAGRAMMATIC MEDIAN SECTIONS OF AN ARACHNID AND A VERTEBRATE, showing the location of the principal organs and their probable relations; *cerbl.*, cerebellum; *cer. h.*, cerebral hemispheres; *g. h.*, ganglion of parietal, or pineal, eye; *hy.*, hypophysis; *inf.*, infundibulum; *ol. l.*, olfactory lobes; *p. eye.*, parietal or pineal eye; *s. vas.*, saccus vasculosus; *thyr.*, thyroid.

(3) That the old mouth and œsophagus of the invertebrates is still present, a useless, heretofore unintelligible, rudiment, in its proper place in the floor of the brain of all vertebrates. This old passageway

is there known as the infundibulum and the saccus vasculosus; it was completely shut off from the outside world by the closing of the brain tube during the process of embryonic growth. (4) The present mouth of the vertebrates is a new one; it arose through the transformation of the so-called "dorsal organ," or cephalic navel, an organ of obscure function, but one that is present in all arthropods near the place where the new mouth of the vertebrates ultimately appears. In the arthropods it may serve as an organ of attachment, and at certain stages of development affords a temporary passageway into the alimentary canal. In other words, the arachnid brain could not continue to grow in volume, and in the particular way in which it had been growing, without closing up the old mouth, and without forcing the jaws farther and farther apart, until they reached the opposite side of the head. Here they converged toward the cephalic navel, which then became a permanent opening and was utilized as a new mouth to take the place of the old one that was being closed up.

Again, in still other words, we are here dealing with a series of interlocking, internal organic adjustments that ultimately reached a condition of unstable equilibrium. A radical and comparatively rapid readjustment then took place, which led to a new condition of great stability. This situation constituted a great crisis in the evolution of this phylum, perhaps the most momentous crisis in the history of organic evolution. But these revolutionary events were brought about in an intelligible way by the cumulative action of long-established methods of growth, which can be traced through the arachnid stock up to the point where the ensuing events appear inevitable. The actual consummation of them marks the transition from the vertebrates to the invertebrates, and the beginning of a new class of animals. From the nature of the case, the transition must have taken place somewhat rapidly, and it probably occurred at some time during, or before, the Silurian period. The paired jaws of the adult ostracoderms are intelligible only on the assumption that they represent one of the early phylogenetic stages of this process.

VII. The Record of Paleozoic Events in Modern Vertebrate Embryos

The general way in which this metamorphosis took place is still recorded in the embryonic history of the vertebrates to the present day, for we can readily observe, in many vertebrate embryos, the shutting up of the old mouth within the brain chamber, the transfer of at least three pairs of jaws to the opposite side of the head, and their union around the new mouth.

In the embryo of the frog, for example, three pairs of rudimentary

jaws may be seen after they have reached the hæmal surface and are assembled around the new mouth (Fig. 8). Ultimately the first two

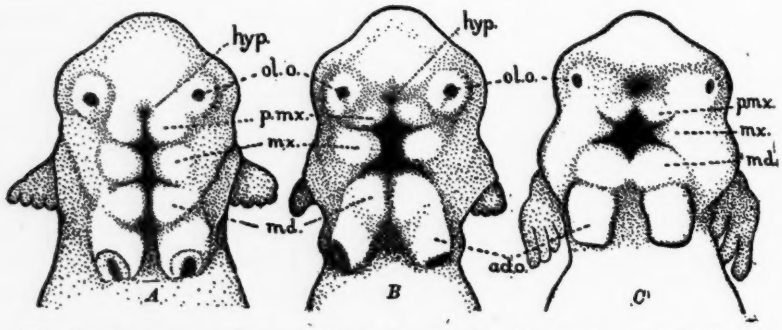

FIG. 8. HEAD OF AN EMBRYO FROG, showing the three pairs of primitive jaws derived from their invertebrate ancestors, and their union to form the unpaired jaws typical of the vertebrates.

pairs fuse to form the fixed upper jaw, and the third pair forms the lower jaw.

The same three pairs of invertebrate jaws are present in the embryonic stages of man. They occupy the same relative positions as in the frog, and their subsequent history is the same (Fig. 9, *A*). Their presence and mode of growth largely control the architecture of the

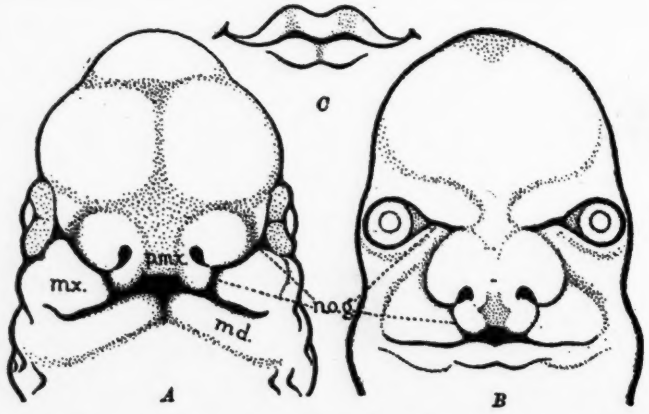

FIG. 9. FIGURES ILLUSTRATING THE MODE OF GROWTH OF THE HUMAN FACE. *A*, human embryo, a little more than a month old, showing the traces of invertebrate jaws in the mandibular, *m. d.*, maxillary, *m. x.*, and premaxillary, *p. mx.*, arches. *B*, embryo a little less than two months old, with the preceding parts nearly united. *C*, mouth of adult, the contours showing its elemental structure.

human face. In rare cases they fail to unite in the normal way, giving rise to such defects in the adult as hare lip, cleft palate and open tear duct (Fig. 9, *B*). Even in otherwise normal faces, the presence of a pronounced "Cupid's bow" mouth, or prominent lateral lobes on the

upper and lower lips, may be regarded as the last outward expression of this primitive condition (Fig. 9, *C*). Thus it appears that the growth of the human face is still dominated by the same forces that have been observed in the remote arachnid ancestors of the vertebrate stock.

There are many other organs of man, especially those in the head, as, for example, the hypophysis cerebri, thymus, thyroid and pineal eye, that have their origin in the arachnids, and it is there that we must look for a better understanding of their significance.

VII. Conclusion

When, in the manner indicated above, we have united the upper and lower sections of the animal kingdom to form one great phylum or highway of evolution, we observe an amazing uniformity and stability in the basic structure and mode of growth of all the animals belonging to it. The direct course of evolution within such a definitely and narrowly circumscribed path, during untold millions of years, and under widely different conditions, clearly indicates, in my judgment, that neither the haphazard shuffling of "hereditary units" in sexual reproduction, nor external environment, nor use and disuse, nor natural selection, has been the chief directing agent in organic evolution. At best, they are of secondary, or subordinate, or intermittent value. The primary and ever present creators of organic structure appear to have been a universal, persistent power of growth, rigidly controlled by the inherent nature of organizable materials; and the internal conditions successively created by growth and organic association.

THE NORTH AMERICAN INDIANS OF THE PLAINS

By Dr. CLARK WISSLER
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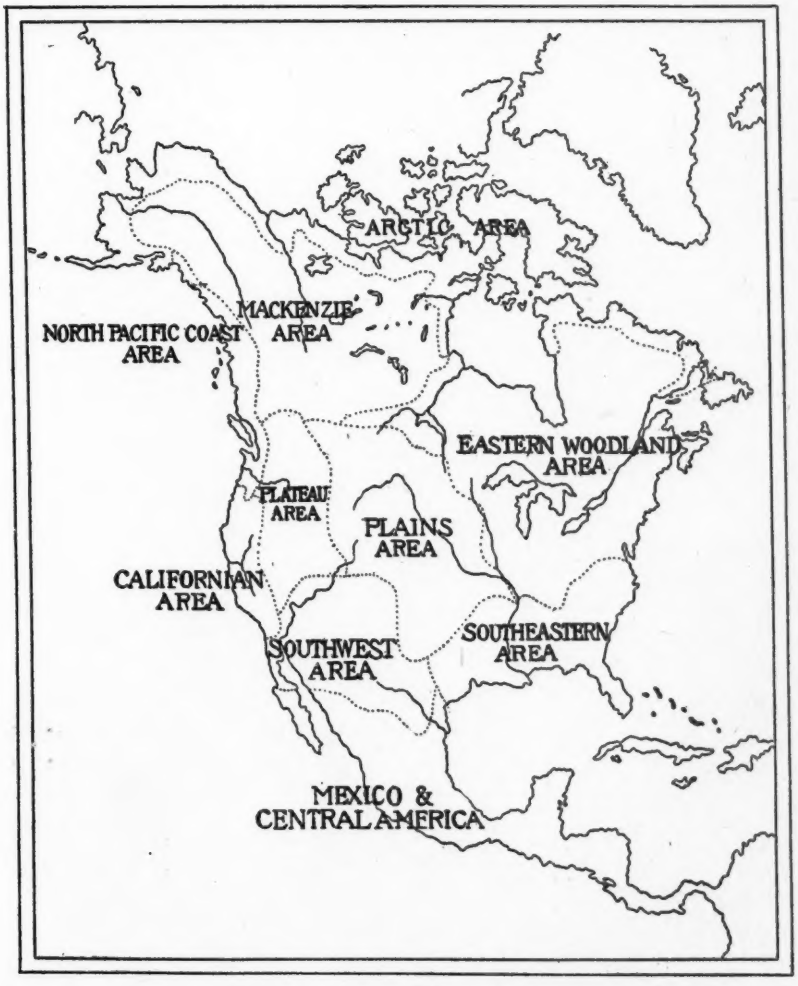
ANTHROPOLOGY is one of the newer sciences. Its development during the past ten years makes clear that regardless of the original meaning of the term anthropology, and, in spite of any one's opinion on the subject, it is primarily a culture study. Culture is here used in a technical sense to designate the complex of social and intellectual activities constituting the life of a native tribe or a group of people. One of the most engaging problems of our time is the origin and mode of development of this culture, which is, after all, the distinctly human character that differentiates man from the animals. Modern anthropology has made this its chief problem and has thus set itself over in contrast to biology which concerns itself with man only in so far as he has animal characters. The theory of evolution was devised as a working scheme for the study of animal characters and has therefore little direct bearing upon anthropological problems, notwithstanding the fact that formerly many anthropologists tried to make it their method also. When it became clear to all that the study of man must concern itself with the distinctly human characters, and delegate his distinctly biological problems to biologists, anthropologists began to formulate their cultural conceptions, which is now their working scheme in just the same way that evolution is the method of biologists. Unfortunately, the culture problem appears peculiarly difficult and complex and has, like evolution, become the battle ground for several incompatible theories of origin and growth. Yet, in the course of its labors anthropology has accumulated an unusually large collection of data and has so systematized its results that whole continents may now be divided into culture areas. For some of these areas our information is now so complete that one may form some idea of what went on within their borders in definite periods of time. The anthropological method in such cases is decidedly empirical, for everywhere interpretations are regarded as permissible by historical analysis only.

As an illustration of what has already been accomplished in anthropology, we may attempt a brief résumé of the Plains Indian culture in North America. In North America, as a whole, anthropologists usually recognize from ten to eleven more or less clearly defined culture areas, the approximate borders of which are indicated on the accompanying map. Yet, in most cases these divisions are not absolute, but relative, for rarely can a group of Indians be found anywhere,

however small, that does not show some of the cultural traits of all its immediate neighbors. One of the most striking characteristics of culture distribution is the constant intergradation of traits, so that only in exceptional instances can the cultures of even two neighboring groups be considered exactly alike. Nevertheless, certain groups often possess in common highly characteristic traits, whence they are said to be of the same general types. The divisions on the accompanying map mark off the limits within which the respective sets of characteristic traits seem



CULTURE AREAS IN NORTH AMERICA.

to predominate. Thus, the various tribes of Plains Indians have a number of peculiar traits whose distribution in more or less complete association is taken as indicating the geographical extent of a type of culture.

One of the most conspicuous marks of Plains culture is the relation of the Indian to the buffalo. Though the buffalo, or bison, was at one time widely distributed in the Mississippi Valley, it seems to have been chiefly at home in the treeless areas of the west. After 1800, at least, the large herds were found in the great open stretches of country, east of the Rocky Mountains, or the long narrow white area in our forestry map. While this was the region in which the herds were thickest and typical, there was also a fringe on all sides, but especially to the east, of small random groups of buffalo. We thus see a faunistic distribution making it possible for Indians in the heart of the area to live entirely on the buffalo, while their neighbors could to varying degrees derive partial support from the same source. This is about what observation shows to have been the case.

From the time of exploration to 1860, or later, all the tribes of Indians living within the great treeless area east of the mountains made the hunting of the buffalo their chief occupation. They cultivated nothing and used only a few wild fruits and roots to supplement their almost exclusive meat diet. Reference to the forestry map will show how the wooded area fringes out into the Plains. Now, the Indians living in this fringed area also hunted buffalo, but not exclusively, for they raised maize, beans and squashes. Again, on the west in the open country between the mountain ranges, the tribes occasionally hunted buffalo; but, though they did not practise agriculture, they gathered great quantities of wild grass seeds which when ground and baked formed a considerable part of their diet.

Thus we see that by taking the use of the buffalo as an index of culture we may roughly group the Indians of the Plains under three heads: the typical or primary tribes, the eastern or semi-agricultural tribes and the western or plateau tribes. If we seek further to characterize the culture of the typical group we find the following conspicuous traits: the use of the tipi all the year round; in historic times, the use of the horse; in earlier times the use of the dog for transportation by travois; an organized camp circle and police system for the regulation of the buffalo hunt; a religious ceremony known as the sun dance, and a highly individualized decorative art. Waiving several minor traits, we may take these as determining characters in the typical Plains Indian culture.

On the tribal map we have used an asterisk (*) to distinguish those clearly manifesting these traits. As previously stated, we must not expect every tribe in this group to manifest every typical trait, for here as elsewhere the gradation of culture is in evidence. Further, the tribes differ as to the degree to which they assimilate cultural elements. For example, the Comanche had no sun dance and a rather weakly organized camp, but otherwise had the typical traits. The Teton-Dakota, on

the other hand, seems to have all the before-mentioned traits in full function and for that reason the most typical, whereas the Comanche seem to stand at the other extreme.

Turning now to the eastern group, we find all of them cultivating maize and in most cases using a more permanent bark, mat, or earth-

THE INDIANS OF THE PLAINS.

The ranges for the various tribes are approximately indicated by the positions and extents of their respective names. As a rule, these tribes did not respect definite boundaries to their ranges, each tribe claiming certain camping places, but otherwise hunting and roaming where it pleased. The typical Plains tribes are designated by a star and range north and south across the area. To the east of them are the tribes practising some agriculture, perhaps in imitation of the Woodland tribes. On the west are a few tribes whose position is quite uncertain; hence the boundary for the culture area has been drawn through their range, thus giving them an intermediate position.

covered house. The most curious thing is that in this area this type of house seems to be associated with agriculture, because the houses are usually placed near the fields and occupied only during the planting season. In many cases, when not engaged with their fields, the whole tribe would take to tipis or other temporary shelters and roam about hunting buffalo. Even in midwinter, the Omaha and Santee-Dakota

left their earth and bark-covered houses to dwell in tipis. When out after buffalo many of these tribes used a camp and police organization similar to that of the typical Plains group. Other traits, such as the sun dance and sign language, occur but occasionally. The members of the typical group were neither potters nor weavers, but in the eastern group we find some weaving and some pottery, though not so highly developed as in the far east and south. Our eastern Plains group thus stands as an intermediate or transitional culture, between that of the typical buffalo-hunting Indian of the west and the typical sedentary Indian of the Ohio Valley.

In the same way we could show that the tribes to the immediate west are transitional between Plateau and Plains culture, because they have traits common to both.

So far, we have considered culture alone. Anthropologists usually classify people in three ways: language, culture and anatomical characters. Strictly speaking, language should be included in culture, but because of the peculiar difficulties in linguistic research it is more convenient to separate the two. The tribes enumerated in the map speak languages belonging to seven distinct families (Sionan, Algonkin, Caddoan, Kiowan, Shoshonean, Athapascan and Shahaptian) and have more than twenty separate languages. Six of these seven families are found in other culture areas and in some cases widely distributed over the continent. As is well known, there is no apparent correlation between cultures and language, for should we superimpose linguistic and culture area maps there would be no significant correspondence. The same may be said of anatomical type.

We may now consider some of the important problems raised respecting the culture of the Plains Indians. Everybody interested wants to know how and when their culture developed, but all problems of this kind have proved particularly difficult, so that no one can yet say even approximately by what means cultures came about. On the other hand, we have sufficient data from some culture areas of the world to form some idea as to what went on therein within a given period of time.

Several more or less extreme theories have been proposed to account for culture. One is that, in the main, each group of people, independent of every other, worked out and created its own culture. The opposite view is that independent invention is extremely rare, so rare that we may assume all like traits as due to inter-tribal borrowing, or historical contact, until we find evidence to the contrary. The present tendency among American anthropologists is to take the middle ground and stand for empirical methods in that both may be true to a degree and that each culture is to be considered upon its own merits without regard to an initial assumption. To them it seems unnecessary to assume anything as to origin until there is real evidence lending itself to a particu-

lar interpretation. It is conceivable that a tribe may build up its culture by some independent inventions and by some borrowing from its neighbors, all of which may perhaps be revealed by the careful analysis of neighboring cultures and a comparative study of their traits. If we

THE DISTRIBUTION OF FORESTS IN WESTERN UNITED STATES.

The shaded portions of this map mark the areas originally covered with trees. The true plains extend from north to south along the eastern border of the Rocky Mountains. On the west, trees are found on the sides of mountains; on the east, they stretch out into the plains along the margins of the streams. Reference to the tribal map shows how the typical group ranges in the open plains while the eastern agricultural village group lives in the partially forested belt. On the west the plateau group appears to range in the open stretches among the mountains.

apply this method to the Plains we find an easy line of approach. Some years ago, Mr. Mooney published his objective study of the ghost dance religion, a curious religious movement originating in one tribe and

quickly spreading to several tribes of Plains Indians. In this case, there can not be the least doubt as the events are a matter of history. Again, at the present day the mescal ceremonies are working their way up from the south among the Plains tribes; this is also a matter of history. In addition to these absolute examples of cultural borrowing, we have cases like the grass dance ceremony, now found in all parts of the area. We have the testimony of several tribes to the effect that this ceremony first originated with the Pawnee. The Teton-Dakota claim to have obtained it directly from the Pawnee about 1870; the Arapaho and Gros Ventre claim to have borrowed it from the Dakota; the Gros Ventre claim to have taught it to the Blackfoot about 1883. While these statements of the Indians need not be taken as absolutely correct, their significance can not be ignored. There are still other traits like the sun dance which are found in the same essential forms among many tribes of the area, but concerning which the Indians have no definite historical knowledge. In this class also must be placed the more objective traits, like tipis and decorative designs. Now, since we have direct historic evidence of borrowing in some cases, the testimony of Indians in others, and still others in which we see all the secondary signs of borrowing, it must be admitted that a strong case has been made for the spread of culture by inter-tribal borrowing.

While borrowing will thus account for the distribution of traits, it can not answer the question as to their origin. For each trait we have a separate problem, since to be borrowed it must have been invented somewhere first. To solve this problem actual historical data are needed, something that is in most cases unattainable, but on the other hand, certain conclusions seem justifiable.

We note that many of the more material traits are peculiarly adapted to the bison-hunting life and to the habits of a semi-nomadic people. This seems reasonable, because many of them are rarely found outside of the Plains area. If this is granted, it seems proper to conclude that they must have been invented by some of the Plains group.

Another related problem is that of migration or origin. For the Cheyenne we have some historical data, the import of which seems to be that they migrated from the Woodlands to the Plains about two centuries ago, where they must have changed in culture very rapidly to become one of the typical tribes, as they were found to be in later years. It is also quite clear that the Sarsi, Plains-Cree and Plains-Ojibway came out of the northern and eastern forests into the Plains something more than two hundred years ago. As to other tribes, we have no data. There is ground for an assumption, however, in linguistic relationships. Some people say it will not do, for example, to say that the Algonkin tribes in the Plains migrated thither on the ground that the greater part of the stock lived in the Woodlands, for it is conceivable that the reverse may

have been true. On the other hand, since the most widely distributed stocks (Algonkin, Athapascan and Shoshone) have minor representation in the area, it seems unlikely that the Plains should have been the cradle land for all. The difficulty is to find proof for any one stock. Nevertheless, it seems reasonable to assume that some of the tribes came there by migration, bringing with them cultures of another sort, as did the Cheyenne and Plains-Cree in historical times. We should then have a period during which various cultural groups were introducing and adapting themselves to new conditions. The most reasonable theory, for the origin of Plains culture, therefore, is that it was the joint product of many tribes, some working out one trait, others again different traits, which by tribal contact and interaction were gradually diffused over the area. In other words, the culture as a complex was worked out by the Plains Indians themselves, but probably not by any one group and probably not without very material aid from tribes in other culture areas.

In some of the older literature we find the belief that there is a more or less steady upward trend in the affairs of man and that there comes a time in the careers of all peoples when they change from a nomadic to a sedentary agricultural life. While as a general principle it is clear that there must have been a time when agricultural groups changed their less sedentary life, it would not be correct to infer that the Plains Indians were always nomadic. Mr. Mooney has made a good case for the Cheyenne as formerly living in the fringed area to the east where they raised maize, but later moving out into the Plains and becoming one of the strikingly typical hunting tribes. In this case the change was radical. It is sometimes regarded as fair to assume that the Arapaho went through the same transitions, but there are no positive data. On the other hand, the Dakota may have followed the reverse process, though we can not be positive, for some of the early Jesuit writers say that in their day none of the Dakota were given to agriculture, while later observers found the eastern division, or Santee-Dakota, raising maize, beans and squashes. The tendency has been to assume that all the Dakota were once agricultural and that the Teton division abandoned the practise when moving west of the Missouri River. The chief objection to this view is that in some of the earlier literature we find evidence that the Teton themselves had no traditions of ever having practised the art. This taken with the positive statements of the Jesuits makes a good case. Further, we find that the tipi was used by all the Dakota as their chief dwelling and was by them so regarded, in spite of the fact that when tending their fields the Santee division resided in bark-covered cabins. This tendency to make the tipi the primary dwelling was quite widely distributed in the area and suggests that agriculture may have been but recently introduced to some of the buffalo-hunt-

ing tribes living along the fringe to the eastern forested area. We have then rather good evidence that cultural transitions went on in both directions within the Plains area. On one side were the typical non-agricultural tribes in the midst of buffalo, on the other were the forest tribes living in fertile valleys amid the trees with their small fields of maize; between them along the Mississippi, the lower Missouri, the Illinois, etc., were interspersed prairies and woodlands. Naturally, the people in this middle ground might take to alternating in buffalo hunting and planting, finally some going over entirely to the one or the other. Thus we had, no doubt for many decades, a shifting of culture influences, now in one direction, now in the other, and while we have here no evidence of a fixed direction of development we do have what may be taken as a typical example of how a people develop culture. In general, we believe that the facts warrant the assumption that the typical Plains culture was developed in the heart of the area and was the composite result of independent invention and the adaptation of intrusive cultural traits from the east, south and west.

HEREDITY AND THE HALL OF FAME

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WHAT is there in heredity? Ask the horseman, the dog fancier and the horticulturalist, and you will find that a belief in heredity is the cardinal point of all their work. Among animals and plants nothing is more obvious than the general resemblance of offspring to parents and the stock from which they come. With the highest-priced Jersey, the blue ribbon horse or a prize-winning dog, goes always the pedigree as the essential guarantee of worth.

So in the general bodily features of human beings, no one questions the great force of inheritance or is surprised because those close of kin look very much alike. Similarities in eyes, nose, mouth, complexion, gestures or physique are accepted as a matter of course, and we never stop to wonder at what is in reality one of the greatest of all mysteries, the substantial repetition of the same sort of beings generation after generation. If heredity does so much in moulding the physical form, may it not do as much in determining the shape and quality of the brain, in short, the mental and moral man in his highest manifestation of genius—indeed the ego itself?

Here we find differences of opinion, for man usually thinks of himself as in part at least a spiritual being, free to act according to his own will, unsubject to the laws of matter. In addition there is the fixed belief in so many quarters, that in the development of character and personality surroundings are of the first importance.

Thus heredity, environment and free will may be called the three rival claimants in the causation of mental and moral traits.

The last two have had many supporters, especially among philosophers and theologians. All the great schools of the past have taught that man's proneness to good and evil was either a fixed principle implanted within him without reference to heredity, or else was something to be modified by an effort of the will or by the influence of surroundings.

The advocates of environment have been, and still are, numerous, especially among the educators and all those who hope to make over the world by drastic reforms, or are interested in improving the condition of the lower classes.

Who then are the advocates of heredity? This view has been largely championed by the scientists and is of comparatively recent de-

velopment. The Darwinian law of the origin and descent of man has undoubtedly indirectly contributed to a growing belief in the force of heredity and has acted as a stimulus to its more exact study. Scientists are assembling facts, and making accurate measurements where once they were content with vague arguments and theories.

The writings of Sir Francis Galton show that among Europeans a large percentage of the most eminent men (about half the entire number) have been closely related to other more or less eminent persons. This, however, leaves the question open how far unequal opportunities, differences of education, and social influence may have favored the close relatives of distinguished men.

In Europe the caste system counts for much, and family patronage may be thought to be at the bottom of many a public recognition of distinction. But it can not be due to anything characteristically European that so many of the great men of the older civilizations of the world are so often connected with others of the same type. For what are we to say when the truth becomes discovered that right here in America under our free and democratic institutions the same facts are to be found?

Galton mentions only three or four Americans, but a careful analysis of our own history speaks no less strongly for the inherited nature of exceptional ability.

The Lees of Virginia, the Livingstons of New York, the Adamses, Quincys and Lowells of Massachusetts, all illustrate the force of hereditary intellect. It is claimed that there are no less than 1,400 superior Americans descended in a direct line from Jonathan Edwards, the great philosopher of Puritan New England, whose blood has run through thirteen college presidents, sixty-five professors, and many principals of important academies.

The Edwards blood has produced more than one hundred lawyers, thirty judges, and some sixty more have attained distinction in authorship, the latest being Mr. Winston Churchill, of New Hampshire. They have been mayors of New Haven, Cleveland and Troy, governors of South Carolina, Connecticut and Ohio, and many diplomats, congressmen, senators and one vice-president of the United States are recorded among their number. Railways, steamship lines and banks have also claimed their talent, but in general Edwards traits have found their outlet in professional life.

The two most notable families in America, considering descent in the male lines alone (the remarkable Edwards showing includes the female lines as well), are the Lees and Adamses, with the Lowells pressing close in third place. Taking into account international as well as local fame, probably Henry Adams, who settled in Braintree, Massachusetts, in 1632, has the honor of being the progenitor of more distin-

guished descendants in various male lines than any other American who has ever lived.

In Jameson's "Dictionary of United States History," and Lippincott's "Biographical Dictionary of the World" are included 13 Lees, 11 Adamses, 10 Lowells, 9 Dwights, 8 Trumbulls, 7 Livingstons, 7 Bayards, 6 Irvings, 6 Sewalls, 6 Prescotts, 5 Channings, 5 Edwardses, 5 Mathers, 5 Randolphs and 5 Winthrops, and over one hundred other families in which from two to four noted Americans can be found closely related to each other. This is without considering consanguinity through mothers and daughters.

When it comes to our greatest men, such, for instance, as are honored by tablets in the Hall of Fame upon the Hudson, more than half show eminent relationships on the above basis. Whether all names properly belonging in this most exclusive temple of the immortals have, or have not, been included, makes little difference in the present argument. No one can fail to pay homage to the names that are there. The 46 celebrities of the Hall of Fame have been selected only from those Americans who have been deceased at least ten years. They have been elected only after careful deliberation, the names of candidates being voted on by a committee of a hundred, made up of citizens well qualified to pass judgment on such matters. College presidents, historians, editors, financiers, scientists and chief justices form the committee. The next election will take place in 1915.

Now if the family history of these 46 preeminent Americans be carefully looked into, they show an extraordinary amount of blood relationships with other men not quite so celebrated it is true, but still men in every sense entitled to the term "eminent," and men whose lives and achievements have added to the luster of their country. Professor Jameson's "Dictionary of United States History" with Lippincott's "Biographical Dictionary of the World" together contain separate sketches for only about 3,500 Americans. There must have lived at least 35,000,000 adult persons from the first settlement of the country to the present generation.

It is very difficult to get any conception of vast numbers of people or of figures in the millions. A considerable stretch of the imagination is necessary. Think of a line of men 35,000,000 feet long. Such a line of 35,000,000 men and women, standing one behind the other in single file, would stretch from the Capitol at Washington to San Francisco, and then bend up to Alaska. In such a line of fame, George Washington, by common consent, as the Father of his Country, stands number one and Abraham Lincoln stands number two. All those within the "3,500 group" would be standing well within one mile of the dome of the Capitol, while the 46 elect of the Hall of Fame would be within the rotunda itself. This means that all those in the "3,500 group" are as one in 10,000 of the entire population.

Suppose the average man or woman to have as many as twenty close relatives—as near as an uncle or a grandson. There can be then only about one person in five hundred who can claim close relationship to an "eminent" man. Those whose names are in the above dictionaries are, on the contrary, related to each other to the extent of about one in five. If the more celebrated among these be alone considered, it will be found that the percentage increases so that about one in three is related to some one within the group. This ratio increases to more than one in two when the families of the forty-six Americans in the Hall of Fame are made the basis of study. If all the eminent relations of those in the Hall of Fame are counted, they average more than one apiece. Therefore, they are from five hundred to a thousand times as much related to distinguished people as the ordinary mortal is.

The following great Americans whose names adorn the Hall of Fame show eminent relationships according to the test.

George Washington was the uncle of Bushrod Washington, justice of the Supreme Court of the United States.

Thomas Jefferson came from plain people on his father's side, but his mother was of the old and distinguished Randolph family. The great orator John Randolph, of Roanoke, was his second cousin, but is too far removed to be counted as a "close" relation. Jefferson's daughter Martha married Thomas M. Randolph, governor of Virginia, and their son, Gen. George Wythe Randolph, counts one "close" relation mentioned in the dictionaries of history.

John Marshall, the greatest American jurist and one of the great jurists of all time, is connected with one of those in the second (or 3,500) group. His nephew, Thomas F. Marshall, reached eminence as a judge and member of Congress. "As a political orator and wit he had great fame."

Abraham Lincoln was the father of Robert T. Lincoln, secretary of war, minister to Great Britain and president of the Pullman Company.

Daniel Webster was the son of Judge Ebenezer Webster, prominent during the Revolution. Daniel's brother "Ezekial acquired a high reputation as a lawyer."

Benjamin Franklin had no great ancestors, but his talents were well transmitted to his descendants. His illegitimate son, William Franklin, became a man of prominence and was the last royal governor of New Jersey. But the more brilliant qualities appeared especially in the Baches of Philadelphia, descendants of Franklin's daughter. Alexander D. Bache was one of the foremost of American scientists.

Alexander Hamilton came of aristocratic lineage on his mother's side; on his father's side, his people were merchants. He married a daughter of General Philip Schuyler, whose mother was a Van Rensselaer. Many of his descendants have become distinguished. John

Church Hamilton and Major-General Schuyler Hamilton satisfy the criterion here imposed.

Few people realize that Washington Irving was one of six Irvings, all distinguished in authorship—three brothers and two nephews of the author of Rip Van Winkle. Washington Irving, therefore, counts five eminent close relations according to the test.

Louis Agassiz, one of the few great Americans of foreign birth, was the father of Alexander Agassiz, who also reached eminence in natural science. Besides conducting many researches of a purely scientific nature, such as deep-sea dredging and archeological explorations, he served the cause of education by princely gifts to the Museum of Comparative Zoology at Harvard; money which he had himself made through developing the now famous Calumet and Hecla copper mines. Alexander Agassiz received the highest honors in the American scientific world, inasmuch as he was president of the National Academy of Sciences and also president of the American Academy of Arts and Sciences. He was also given the Order of Merit by the German emperor.

Jonathan Edwards, America's greatest metaphysical thinker, was one of a great group of interrelated eminent Americans. He is of the first magnitude in a galaxy of stars. With grandfather, son and grandson, he is surrounded by these luminaries of the second rank.

S. F. B. Morse, inventor of the telegraph, is the center of a small and isolated cluster. His father, Jedediah Morse, D.D., is considered "the father of American geography." A brother, Sidney Edwards Morse, won fame as an inventor.

Henry Clay belonged to the distinguished Virginia Clays. Of his four sons who reached maturity, one son, James B. Clay, enters the 3,500 group. He was a member of Congress and prominent politically. He died in 1864, aged forty-seven.

Peter Cooper, the wealthy New Yorker, who was elected to the Hall of Fame as a representative philanthropist, was the father of Edward Cooper, who was mayor of New York from 1879 to 1881 and 1883, and is remembered in history on account of his activity in the overthrow of the "Tweed ring."

Oliver Wendell Holmes was the son of Rev. Abiel Holmes, pastor of the First Congregational Church, Cambridge, Massachusetts, from 1792 to 1832, who in 1805 published "American Annals," the result of great industry and research. "We consider it," says Professor Sparks, "among the most valuable productions of the American press." The son of Oliver Wendell Holmes, the poet, is Oliver Wendell Holmes, of the Supreme Court of the United States.

Robert E. Lee, as every one knows, belonged to one of the most distinguished families in America. Many of his relatives are the sub-

jects of separate biographical articles, those close of kin being his father, one nephew and one son.

James Kent, the celebrated jurist, was the father of William Kent, judge of the United States Circuit Court of New York, a lawyer who gained a high reputation.

Henry Ward Beecher was a son of the noted Rev. Lyman Beecher and was one of five distinguished brothers and sisters, among others, Harriet Beecher Stowe, author of "Uncle Tom's Cabin," herself an elect of the Hall of Fame as of first choice of the electors of 1910.

Joseph Story was called "the most extraordinary jurist of his age." His son, William Wetmore Story, gained most of his laurels in a very different channel. He is considered one of the few great American sculptors.

John Adams, second president of the United States, a member of one of the most notable families that America has produced, claims many distinguished relatives, if distant kinsmen be included. Samuel Adams was his second cousin. Dr. Zabdiel Boylston, noted physician, who was the first to introduce inoculation for smallpox in America, was his great-uncle. If only the close of kin be reckoned, then John Adams counts two in son and grandson.

John Quincy Adams, himself in the inner shrine of fame (elected in 1905), tallies as many as five of the "eminent" class. His position on the pedigree is at the center of the Adams group. With mother as well as father internationally famous, with a son, Charles Francis Adams, the bulwark, during our Civil War, of the rights of the United States in England; and with two grandsons reaching distinction in literature, John Quincy Adams rivals Beecher, Edwards and Lowell in the profusion of his lustrious kinships.

James Fenimore Cooper is not particularly affiliated to others of exceptional gifts. Still, his daughter, Susan Fenimore Cooper, became known as an author and philanthropist. She is in the group of 3,500.

James Russell Lowell had eight eminent close relations. His grandfather, Judge John Lowell, was a member of the convention which framed the constitution of Massachusetts, secured the insertion of the clause "all men are born free and equal" in the Massachusetts Bill of Rights. It is indeed rather ironical that this phrase should be coined by a Lowell. The poet's uncle, John Lowell, was an "able lawyer and political writer." Another uncle, Francis Cabot Lowell, was one of the principal founders of the city of Lowell, to which he gave his name. He was a merchant and manufacturer. The father of J. R. Lowell was Rev. Charles Lowell. Rev. Robert T. S. Lowell, brother of the famous poet, is also noticed in Lippincott's "Biographical Dictionary" as an author. Mary Lowell Putnam, "a distinguished polyglot linguist," was his sister. Her son, W. L. Putnam,

"gave promise of extraordinary genius." He was killed in the battle of Ball's Bluff, aged twenty-one. Another nephew, Col. Charles Russell Lowell, was killed in the Civil War, aged twenty-nine. "He was a young man of great promise," and already one of the most distinguished cavalry officers in the Federal service.

The poetical gifts of William Cullen Bryant showed themselves in a lesser degree in his brother, John Howard Bryant.

William Ellery Channing, one of America's most eloquent preachers, was a grandson of William Ellery, signer of the Declaration of Independence. Two brothers and two nephews of the celebrated divine became eminent in professional life.

General William Tecumseh Sherman counts one "eminent" relative in his brother John Sherman, senator and member of the cabinet.

George Bancroft, the famous historian, counts also one "eminent" relative through his father, Rev. Aaron Bancroft. The father was also noted as an author. Besides a great number of sermons, he published a "Life of Washington" which obtained great popularity.

Thus, 26 of the 46 men in the Hall of Fame show close eminent relationships. In total relationships, they tally 57, which, as already said, is from 500 to 1,000 times what random expectation calls for.

Much might be said concerning the families of others in the Hall of Fame, such as Emerson, Longfellow, Audubon, Eli Whitney, Phillips Brooks and J. Lothrop Motley, but they do not happen to show "eminent" relationships by the method here used.

All the above material has been collected in a systematic way, in order that its value may have a scientific and impartial basis. If the names of more or less distinguished relatives do not have separate articles devoted to them, in the afore-mentioned dictionaries, they have not been utilized in the above list. These two books have been used, not because they are considered infallible guides, but because they are convenient and are good enough for the purpose at hand. The same sort of result would be obtained if any good test were employed.

The proportion is the same the world over, for men of the highest caliber, one in two, or better, show relationship with other distinguished men, and these usually in their own field of activity.

The present writer has investigated the personalities and pedigrees of some 3,000 members of the royal families of Europe—published under the title "Mental and Moral Heredity in Royalty"—and has found that the same principles hold. Nearly all of the great names, or at least more than half, are closely associated by blood with those of similar stamp. About half of all the greatest rulers have been the descendants of comparatively mediocre ancestors; the other half have been the direct and immediate descendants of those as great or nearly as great as themselves. In other words, the vast horde (say ninety-nine

per cent. of the whole) is no more likely to produce a man of genius than is the one per cent. (or less than one per cent.) which, from the standpoint of eugenics, we rightly call the *crême de la crême.*

Thus we see why men like Lincoln and Franklin, who spring from the great reservoir of the commonalty, do not in the least upset one's belief in heredity, provided they do not occur very frequently. For they are the happy combinations of qualities derived from maternal and paternal sources.

All this does not deny that in some ways environment and, possibly, free will, play a measurable rôle in the determination of human fate, but it does suggest that the reliance which has been so freely bestowed on these social, institutional and metaphysical forces has been an exaggerated one.

The high percentages among illustrious men in this country—as high, in fact, as it is in Europe, is a very suggestive point. Opportunities are supposed to be freer in America, and social lines less strictly drawn. We should certainly expect to find in this country, notable names less often running in families; unless, of course, the eugenist's theory that it is nearly all a matter of heredity be indeed correct. At any rate, our much-vaunted American equality, liberty and opportunity have done nothing to make distinction in this country any less of a "family affair" than in the older civilizations of Europe.

THE MAN WHO DISCOVERED THE CIRCULATION OF THE BLOOD

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THE discoverer of the circulation of the blood was a London doctor called William Harvey.

The discovery of the circulation of the blood is the foundation of modern medicine; it was epoch-making, for it made possible that marvelous epoch in which we have seen the laws of living matter discovered and the actual, physical causes of the most mysterious diseases revealed. Harvey closed the dark ages of the science of the living; physiologically he "allured to *brighter* worlds, and led the way." Until it could be known that the blood, the same blood, moved round and round the body under the force of the propulsion of the heart, and that it traversed heart and lungs and all body-vessels in its closed circuit, there could be no physiology, no pathology, no therapeutics, no rational medicine: no such procedure as transfusion of blood. To understand what it was that Harvey discovered, we need to know what was believed as regards the movement of the blood before his time.

The oldest idea of all was that only the veins contain blood, the arteries air. Galen had corrected this latter mistake by tying a cord above and one below a length of artery and cutting out the piece above and below the ligatures; blood, of course, and not air was found inside. It was thought that blood went up and down the veins like the ebb and flow of a tide, that "crude" blood was made in the liver and taken to the heart to be purified. The heat supposed to be produced in this process was believed to make it necessary to cool the heart by drawing in air in the act of breathing, and this was regarded as the function of respiration even as late as the time of Haller, that is, the middle of the eighteenth century. The pulse or opening up of the arteries was regarded as an active thing on their part, blood not being forced into them by the heart but drawn into them by their own suction like a bellows draws in air. But Harvey said the heart is the pump, and the arteries are filled by its forcing its blood into them.

Harvey advanced not one or two but more like a dozen proofs of the circulation. His contention is—the blood in the arteries moves towards the tissues, thence towards the veins, it is collected in the right auricle of the heart, whence it flows to the right ventricle, this on contracting drives it through the lungs, whence it flows to the left auricle, passes to left ventricle and so is ready to be sent to the body again. Galen had

said that almost all the blood passed from the right to the left side of the heart across the septum of the heart, but Harvey, maintaining that the septum was not porous, proved that *all* the blood, not merely some of it, went round by the lungs.

Of course, this pulmonary or "lesser" circulation *was* taught before his time, notably by Servetus and M. R. Columbus; but it was Harvey who first showed that the valves of the heart and the valves of the veins absolutely prevent any other direction of flow except from the veins to the right heart and thence *via* the lungs to the left heart. This doctrine of the porosity of the septum died hard, for we find Harvey, towards the close of his life, attempting to convince an objector—Professor Riolanus—that if only he will pour water into the right heart and tie all vessels to and from the lungs, not one drop will get into the left ventricle.

No one before Harvey had fully understood the venous valves. His own professor at Padua—Fabricius—had talked a great deal of nonsense about them in a treatise entirely devoted to them. Harvey said that they were not primarily for supporting columns of blood, but for preventing any back-flow towards the periphery, seeing that they were present in the veins of the head in which the blood (under gravity) flowed past them with the greatest ease: here, since they *opened* towards the heart, they could not support any column of blood.

In Chapter II. of his great book—the "De Motu"—his chief point is, "the charge of blood is expelled by force," that is, the heart is dynamic for the circulation, a point by no means admitted before his time, for M. R. Columbus denied the heart to be even muscular. Harvey is absolutely clear on this point; he writes:

> It is in virtue of one and the same cause that all arteries of the body pulsate, namely, the contraction of the left ventricle.

Again in Chapter V. he writes:

> The one action of the heart is the transmission of blood and its distribution by means of the arteries to the very extremities of the body.

In Chapter VI. he gives a remarkably good account of the circulation through the fetal heart, that is, before lungs are developed; it is surprisingly accurate to have been done three hundred years ago. In Chapter VII. he returns to the circulation through the lungs and clearly arrives by induction at the existence of capillaries; the word of course he does not use, he calls them "porosities of the flesh," but he understands perfectly that arteries do not become veins without undergoing some complete change in structure and nature. He says if arteries became veins, there would be a pulse in the veins, marvellously good physiology for 1628!

Owing to his having no microscope sufficiently powerful, Harvey could not *see* the capillaries even in those transparent animals which he

scrutinized with his simple lens, but he inferred the existence of capillaries without ever seeing them. There are at the Royal College of Physicians in London three large boards on which he has dissected out the blood-vessels of the human body to the extreme limits which his scalpel would allow him. There they are to this day, a testimony to his eagerness to find those vessels in which the arteries ended. But it was not to be: I sometimes call these "tabulæ Harveianæ," his "sorrow's crown of sorows," for his finest dissection could not reach the capillaries. Three years after his death, in 1660, the great Italian naturalist, Marcello Malpighi, at Bologna, was the first of all men to see the living capillaries in the lung of the frog; he saw the blood coursing through them exactly as Harvey had predicted. Systemic capillaries were first seen in 1688 by Anthony van Leeuwenhoek, the Dutchman, at Delft.

Chapter VIII. contains the *epoch-making metaphor,* "motion as it were in a circle," "motion of the blood we may be allowed to call circular." Chapter IX. contains the argument from quantity, one of the subtlest in the whole book. It is a matter of very simple calculation to show that in an hour or two the heart will eject far more blood than the body possesses unless the blood comes back again to the heart: Harvey showed that the body of a sheep does not contain much more than about four pounds of blood, but that in an hour quite seven pounds of blood have passed through the heart. Now the heart can not deal with more blood than the body possesses, therefore blood is continually returning to the heart. Harvey, believing that the blood carried the nourishment to all parts, applied this view to an actual case of pulsating tumor which he had to treat: he tied the artery so tight as to stop the blood-flow to the tumor which shortly dried up from lack of nourishment. He had the full courage of his convictions; he applied his scientific knowledge to a surgical case for the relief of a suffering man. Chapter XVI. has the most interesting application of all; the argument based on the general or systemic effects of local absorption. Harvey points out that poisoned wounds, what we should call local infections, can poison the whole body; certainly this could not be so unless there was a carrying of the poison round through all the body, but that is just another expression for circulation. Were it not for the circulation, food absorbed where it is digested could never be distributed over the whole body: the circulation accounts equally for the universal distribution of food, drugs and poisons. Not until this was understood could there be a rational basis for physiology or the healing art; Harvey divides the empirical from the rational, for ever. In this way we may say emphatically that the discovery of the circulation was epoch-making, it brought in the era of experiment in biology, for Harvey experimented; had to do so in order to see nature at work; he tied this vessel and that, he looked into the body for himself; he was done with what Aristotle or Galen had said, done with library or arm-chair physiology.

I sought to discover the motions and uses of the heart from actual inspection and not from the writings of others; at length, and by using greater and daily diligence and investigaion, making frequent inspection of many and various animals, and collating numerous observations, I thought I had attained to the truth, etc.

He says he has gone to work, "in order that what is false may be set right by dissection, multiplied experience and accurate observation." No short cuts, no shirking of trouble: no royal road to physiology. He goes on:

Doctrine once sown strikes deep its root, and respect for antiquity influences all men. Still "the die is cast," and my trust is in my love of truth and in the candor of cultivated minds. Harvey was a gentleman.

Harvey demonstrated to any one who wished to see; to Hoffman at Nüremberg, to Vesling at Padua, to King Charles I., to whom he showed much: the king went with his physician to see a patient, a son of a Lord Montgomery, whose heart was congenitally exposed (ectopia cordis). Harvey dedicated his "De Motu" to the king.

Harvey did not apparently think of injecting the vascular system with some kind of colored liquid, as was done shortly after his death by several observers, notably by Ruysch of Amsterdam. But even had he so filled the vessels and therefore the capillaries, he could not, in the absence of all histological technique, have seen them in the opaque tissues. Harvey made the capillaries a logical necessity, Malpighi made them a histological certainty. But Harvey did much more than discover the mechanism of the circulation. He attempted with all the assiduity of his nature to discover the mechanism of reproduction and the course of development of the embryo.

Inexorably hampered by having no microscope wherewith to explore the ultravisible, Harvey nevertheless reached conclusions which have stood the test of time. He insisted that that small white speck on the surface of the yolk (the cicatricula) was the precursor of the chick, that the whole future animal came from a fertilized germ, and that every living being came from an egg (ovum). Such were by no means the views held by the majority of naturalists in his day; he was once more ahead of his time. Not until 1827, by von Baer, was the full truth of these things substantiated.

Harvey when Warden of Merton College, Oxford, where he was for two years when Oxford held out for Charles, associated himself with a Dr. Bathurst in experiments on development. Dr. Bathurst had hens laying eggs in his rooms in college, so that the embryo chick might be studied at any stage of its evolution.

Harvey furthermore wrote a treatise on respiration and one on insects; these, along with notes of post-mortem examinations (pathological anatomy), were all destroyed when his rooms in Whitehall were ransacked by the soldiers of the Parliament in 1642, an indelible stain

on the records of that assembly. With Newton and Carlyle, Harvey is in distinguished company as regards the destruction of manuscripts.

William Harvey, the eldest of the nine children (seven sons and two daughters) of Thomas Harvey and Joan Halke, was born at Folkestone on the south coast of England on April 1, 1578. Queen Elizabeth was at this time on the throne. His father was a prosperous yeoman, and in 1600 mayor of Folkestone. The Harvey family had not been a medical one; William was the only son who did not go into business.

There still exists a memorial brass to Harvey's mother in the parish church (St. Mary's) at Folkestone: she was only fifty years old at the time of her death. From a nephew, Daniel Harvey, are descended the noble families of Winchelsea and Aylesford. One of William's brothers was called Eliab; he became a Turkey merchant in London and managed his brother's affairs; for, like many geniuses, William was "constitutionally incapable of making a bargain." Eliab managed his money matters so well that William was always quite comfortably off. One of Eliab's descendants was Sir Eliab Harvey, G.C.B., who commanded the *Teméraire* at the battle of Trafalgar.

In 1588, when ten years old, Harvey was sent to the King's School at Canterbury, where he remained five years. It is thus perfectly possible that from his home on the English Channel he may have witnessed some of those engagements which led to the overthrow of the Spanish Armada, which occurred in August, 1588. When sixteen years old he entered Gonville and Caius College, Cambridge, on May 31, 1593. The entry is still to be seen in the records of that notable seat of medical learning founded by John Keys, the man who introduced into England from Italy the academic study of anatomy and the dissection of the human body as an essential means thereto. Harvey took his B.A. degree in 1597. As Harvey's father was a man of means, he could afford to send his son to study at the great University of Padua in north Italy, at that time and for long afterwards the most famous of the European schools of medicine. Harvey entered the University of Padua in 1598, and left it as doctor of medicine in 1602. The original of his doctor's diploma is in a glass case in the library of the Royal College of Physicians in London. I have had this priceless document in my hand; it is printed in the Latin language on vellum; the margins have been beautifully decorated by some artist in colors which are still perfectly fresh.

As an undergraduate, Harvey seems to have been a representative student, for he was elected three years in succession concilarius of the English nation, as it was called. The students at Padua were divided into nations for the purpose of voting for their rector, a system, for instance, only just abolished in the University of St. Andrews, Scot-

land. Padua recognized the English and Scottish nations as late as 1738. The MSS. lists of students for the sessions 1600–01 and 1601–02 begins with a "Gulielmus. Arveius. Anglus." These representatives of voting nations had the privilege of having their "stemmata" painted up somewhere within the university precincts. After a most laborious search, Harvey's stemma was found covered with whitewash on the concavity of the roof of the lower court-yard of the university. The master and fellows of Caius College have had it restored in its original colors; and very fine it is with a red ground, a white sleeve and green serpents; above it is the one word, "Anglica," and below it the three words, "Gulielmus. Harveus. Anglus." Precious words, for this is undoubtedly *our* William Harvey, then a youth of twenty-three years, who a little later was to reveal something which was to place his name beside the greatest names in the history of human discovery. He was soon to become an epoch-maker. But as a doctor of medicine later on he would be entitled also to have his coat-of-arms emblazoned somewhere in his alma mater. In March, 1893, after a most tedious search, the rector of that time discovered the shield with Harvey's arms, but so damaged that the inscription which accompanied it was lost for ever.

A few details are preserved to us of the social conditions at Padua in Harvey's time, and they show us a very miserable state of affairs. Food was scanty and bad, there was no glass in the windows, which were of linen; artificial light was extremely costly, and there were no public entertainments. The professor of anatomy was the venerable Hieronymus Fabricius ab Aquapendente, surgeon, anatomist and historian of medicine, a great favorite with the Venetian senate, who were the patrons of the chairs at Padua. The little theater in which he lectured at nine each morning from October to August still exists. It is of oval form, lined with oak, with steep-pitched, narrow platforms (instead of seats) with low rails to lean over to watch the dissection. There is a small cupola in the roof. It was not without some emotion that the present writer stood one September morning on the very spot where there came to Harvey the illuminating thought about the venous valves.

Harvey returned to Cambridge in 1602, when he at once took the M.D. degree at his English alma mater. By 1604 he had entered upon medical practise in London in St. Martin's parish; and on November 24 he was married in St. Sepulchre's church, Newgate, to Elizabeth Brown, daughter of Dr. Lancelot Brown, who had been one of the physicians to Queen Elizabeth. It was the bells of this same church that for many years were tolled on the morning of an execution in the prison of Newgate over the way. The Harveys had no children; his wife predeceased her husband.

In June, 1607, Harvey was elected a fellow of the College of Physicians, not yet Royal; and by 1609 he had been appointed one of the physicians to St. Bartholomew's Hospital, a charity justly proud to remember the fact. In 1615 he was made Lumleian lecturer at the College of Physicians, a post he held until 1656. In 1618 Harvey was appointed physician to King James I. and VI., and in 1631, physician-in-ordinary to King Charles I.

Lecture notes of Harvey's dated 1616, now in the British Museum, show that by that time he was teaching the doctrine of the circulation, but it was not till 1628 that he published with William Fitzer at Frankfort-on-the-Main a quarto entitled "Exercitatio anatomica de motu cordis et sanguinis in animalibus." An epoch-making essay this! and I am not forgetting either Schwann on the cell-theory or Darwin on the "Origin of Species." The "De Motu" is a good example of a great book which is not necessarily a large one; it has only 72 pages. Harvey published his book at Frankfort because of the important book-fair held there annually, so that the work might have a better chance of being rapidly taken up than if brought out in England, then vastly more isolated from the Continent than it is nowadays.

Possibly no epoch-making book had a worse reception. Previously to publishing the "De Motu," Harvey's practise was very large, for he was a skillful surgeon and obstetrician; but Aubrey tells us that after 1628

> He fell mightily in his practise; 'twas believed by the vulgar that he was crack-brained and *all* the physicians were against him.

Harvey was quite alive to the possibility of opposition and even dislike, so truly did he know that anything new is objected to, so difficult is it to overcome mental inertia. Listen to him:

> These views *as usual* pleased some more, some less; some chid and calumniated me, and laid it to me *as a crime* that I had dared to depart from the precepts and opinion of all anatomists. I tremble lest I have mankind at large for my enemies, so much doth wont and custom become a second nature.

He got what he expected, the usual treatment meted out to those who dare to upset what has been believed for a long time; people do *not* like to be disturbed physically or mentally.

From 1628 onwards, Harvey's spare time may be said to have been occupied in defending and expounding his so-called "doctrine" of the circulation, for both at home and abroad all the professors of anatomy were at first disbelievers. Harvey is most long-suffering towards that "tympanitic philistine," as Huxley called him, Riolanus of Paris. He is most courteous to him, he calls him "a learned and skillful physician, and the Corypheus of anatomists." Riolan was physician to Marie de Medici, mother of Louis XIII., and of Queen Henrietta Maria. Harvey met him once at Whitehall.

The great discovery had plenty of opposition everywhere, but I am

particularly sorry to have to say that the first person to write formally against Harvey was a Scotsman, a Dr. Primrose. He had been a pupil of Riolanus; he published his feeble tract in 1630. Harvey never replied to Primrose, probably because his book was sheer Galenism and because he had only just been admitted into the College of Physicians, Harvey being one of his examiners. This Dr. James Primrose was of the same family that gave rise to that of the Earls of Rosebery. A longer, but still weaker, protest was made in 1635 by one Parisanus, of Venice; Harvey did not reply to this, either; there was nothing new in it.

Caspar Hoffman of Altdorf was, in point of time, the next objector, as we gather from Harvey's letter to him dated May, 1636. Hoffman's difficulty is one very typical of the prescientific spirit, the spirit of the middle ages; it is this: Harvey has made out nature to be a clumsy and inefficient artificer in causing the blood to return again and again to the heart to be reconcocted. This objection we should now call teleological; Harvey's reply virtually is, that teleological difficulties must not prevent our drawing conclusions from facts observable in the living animal. Blood constantly pours through the heart in one direction only; if we can not explain this, that must not prevent our admitting that it does so. Harvey virtually says: you must not weight your physiology with a teological load.

The difficulty of Professor Vesling of Padua was neither frivolous nor antiquated, it was a real one: how is it possible for the blood in arteries and veins to be the same blood when it is scarlet in the one and purple in the other? This would be a difficulty to us still, if we did not know the physico-chemical reasons for the change of color. Naturally, Harvey's answer is not any explanation of the change of color; he can only emphasize the arguments of the "De Motu," which are so full and so convincing to those capable of appreciating the experimental method.

It can not be said that Harvey's life was destitute of incident, for his appointment as physician to Charles brought him into contact with many interesting and distinguished people, and led him into many stirring scenes. He accompanied Charles at least on one visit to Scotland, namely, that for his coronation in 1633. We know this, because there exists in the records of St. Bartholomew's Hospital a request for Harvey to absent himself, and that a substitute be allowed to act for him. Harvey was a very great deal with the king and accompanied His Majesty on his hunting expeditions, when he had opportunities of examining the bodies of deer, observations he turned to good account in his work on development ("De generatione").

It can not but be interesting to some of us to know that William Harvey was in Edinburgh. As personal attendant on the king, he

must have been at Holyrood and present at the banquet in Edinburgh Castle given by the Earl of Mar on June 17, 1633, in honor of the king. Charles remained two months in Scotland, from the middle of May to the middle of July, and we have a curious piece of incidental evidence that Harvey was with him all the time.

In his book on development, Harvey has left on record the appearance of the Bass rock "during the months of May and June" in a description he wrote of that island, which he visited for the purpose of studying the embryo in the eggs of the solan goose. His description of the myriads of these birds on the rock would be quite true to-day.

Harvey was at least once actually under fire in a battle of the civil war, namely, at the battle of Edgehill, where he had charge of the royal children, afterwards Charles II. and James II. Aubrey tells us that "a shot from a great gun" made them seek better shelter; we are also informed that Harvey read Fabricius on generation during the battle.

Harvey traveled a good deal on the continent of Europe; from 1631 to 1633 in Spain with the Duke of Lennox; while in 1636, in company with the Earl of Arundel, who was sent on a diplomatic mission to Vienna, he made an extensive tour which included Rome. They visited The Hague, Leyden, Cologne, Nüremberg, Lintz on the Danube, Baden, Ratisbon, Treviso and Venice. The records are still extant of the visit of the party to the English college at Rome; Lord Arundel was a Roman Catholic. To Dr. Weir Mitchell, F.R.S., of Philadelphia, we owe only this very year the publication of a number of previously unpublished letters written by Harvey on this journey to the Lords Feilding and Dorchester. They cast very interesting sidelights on men and manners; but we must not be tempted to linger over them.

At Florence Harvey and the Earl's party were entertained by that celebrated patron of learning, Ferdinand II., Grand Duke of Tuscany. At Nüremberg on this tour it seems almost certain that Harvey's portrait was painted by William van Bemmel. It is the portrait in which the heart and arteries are displayed in a dissection on the right of the figure. He was fifty-eight years old at this date.

A few of Harvey's more notable patients were: King James I., the Lord Chancellor Bacon, the Earl of Arundel, Prince Maurice, brother of Prince Rupert, a son of the Viscount Montgomery, Sir William and Lady Sandys and Sir Adrian Scrope.

Of his friends in England we know the following were of the number: the aged philosopher Hobbes, of Malmesbury; the Hon. Robert Boyle; Robert Hooke, F.R.S., the natural philosopher; Dr. Argent, Sir George Ent, Aubrey the antiquary, and Selden the lawyer.

Of three of his medical pupils—Scarborough, Willis and Highmore

—two have left their names embedded in anatomical nomenclature: in the circle of Willis and the antrum of Highmore.

It was in conversation with Boyle that Harvey admitted that the idea of the circulation came to him after pondering on the way in which the valves of the veins were placed with reference to the heart. Boyle's words are:

> When I asked our famous Harvey, in the only discourse I had with him, what were the things that induced him to think of a circulation of the blood, he answered me, that when he took notice that the valves, etc.

Now it is a very remarkable thing that Bacon in all his writings has not one word on the circulation, though its discovery was such an admirable example of the success of the inductive method he so laboriously recommended.

One other very great Englishman was a contemporary of Harvey, I mean the author of the plays and poems known as Shakespeare's. It has been conjectured that this very gifted person did know of the circulation and made allusion to it in his writings. Having looked into the question pretty carefully, I have come to the conclusion that this writer did not understand the circulation of the blood, although he had some acquaintance with anatomical terms and with the medicine of his day.

The champions of the Harveian "doctrine" were all foreigners, I suppose on the principle that a prophet hath no honor in his own country. The great philosopher Descartes convinced himself of the truth of Harvey's assertions by making a large number of dissections; but Descartes was not a medical man and not a teacher. Professors Sylvius of Leyden, Trullius of Rome and Bartholinus of Copenhagen were all ardent defenders of the Harveian faith. So enlightened a contemporary as Sydenham, the English Hippocrates, was not a convert. An admirable observer, he had, nevertheless, not a receptive mind; it was strong enough, but it was narrow. Alluding to Harvey and his school—the experimental one—he said:

> We *may* know the larger organs of the body, but its minute structure will always be hidden from us. No microscope will ever show us the minute passages by which the chyle leaves the intestine or show by which the blood passes from the arteries to the veins.

This is in his "De podagra" and his "De Hydrope" published in 1683. Sydenham was a little behind the times, for twenty-three years before Malpighi had, by the despised microscope, found the capillaries by which the blood of the arteries of the lung reaches the veins of that organ, and only five years after this statement was made, namely, in 1688, Leeuwenhoek, the Dutchman, discovered the capillaries of the general vascular system. So much for prophecy in biology when it is not based on a direct study of nature!

Some of Harvey's experiences were unique; he dissected the body of one of the oldest men that ever lived, Thomas Parr. Old Parr, a native of Shropshire, died in 1635, aged 152 years; he had lived under nine British monarchs. Harvey found no physical signs of senility in the body, no lime in the costal cartilages. He suggests that the sudden change from the old man's simple fare to the rich food of Lord Arundel's establishment was the cause of death. Harvey tells us that old Parr lived on sour milk and rancid cheese; he thinks he survived in spite of this diet, the followers of Metchnikoff would tell us that he lived so long on account of it.

Another of Harvey's curious experiences was the affair of the Lancashire witches. This reveals the gross superstitions that could flourish in 1634 and engage the attention of the king, a bishop or two, a secretary of state and the Lord Privy Seal. A boy playing truant in the woods in Lancashire swore that he had been carried off by a witch, Mother Dickenson. She bore him over fields and forests till she came to a barn where seven other witches were having supper when, he said, they assumed the shapes of all sorts of animals. This rigmarole and a great deal else was actually believed. The king commanded the Earl of Manchester to order a commission of medical men, one of whom was Dr. Harvey, to empower certain midwives to examine the bodies of these women, to see whether they had any marks on them indicating anything unnatural. The examination was carried out in Dr. Harvey's presence, and, of course, nothing was found. We have no scrap of evidence to make us think that Harvey in any way shared the popular superstition as to these women; he was merely carrying out the royal commands.

In personal appearance Harvey was of short stature; "of the lowest stature" and "little Dr. Harvey" are the phrases used to describe him. At thirty-seven years old, his hair was black; his eyes small and black. He seems to have been restless, full of energy, rapid of utterance, given to gesture and to playing with the handle of a small dagger he wore. His handwriting was exceptionally illegible even for that time. From all we can gather, his temper was irritable; "choleric" is the word used of him again and again. If this was so, Harvey wrote very courteously to his most tiresome opponents, as Professor Huxley has remarked. Seeing that he lived to the age of seventy-nine, and came through the fatigues that he did, he must have had a fairly good constitution.

Harvey was very fond of coffee, a beverage in his day by no means universally taken; and on his own confession he occasionally drank freely of spirituous liquors. In later life he suffered from sciatica and gout, that disease of the intellectual hierarchy. His grandniece told Dr. Heberden in 1761 that her great ancestor, in his later years, sub-

stituted sugar for salt in his food. This observation is rather interesting in the light of the modern notion that excess of common salt leads to a retention of sodium urate in the tissues; it looks as though Harvey had found this out by experience.

As regards portraits of this epoch-maker, we are fortunate in possessing more than one. I have mentioned the van Bemmel, the engraving of which by Houbraken is well known. The oil painting in the upper Library Hall of the Royal College of Physicians, represents Harvey in later life. It was painted by Cornelius Jansen and survived the fire of London. There is also a head by an unknown artist in the National Portrait Gallery in London; this is the portrait reproduced in the memorial edition of the "De Motu" (Canterbury, 1894). In the rooms of the Royal Society in Burlington House, there hangs another head, a portrait of Harvey done by Jan de Reyn; it is undated.

My learned friend, Sir James Sawyer, M.D., of Birmingham, England, points out an interesting difference between the styles of dress in the two portraits, the Jansen and the de Reyn; in the former the collar is that of a cavalier, in the latter of a Cromwellian. Harvey lived eight years under the commonwealth; and Sir James's inference is that he altered his dress to accord better with the more solemn taste prevailing during the period of Cromwell's power.

As regards statues of Harvey, there are only two in the open air in England, as far as I know. One in stone is high up on the pediment of the building of the College of Physicians in Pall Mall where he stands between Linacre and Sydenham: the other is of bronze on a high pedestal on Folkestone Leas; there he stands looking out across the Channel away to those lands where he received his inspiration and where he was first sympathetically understood.

In connection with Harvey's religious position, we have hardly any facts to go on. Some have surmised that because he travelled with the Earl of Arundel, Harvey also must have been a Roman Catholic. I hardly think that a papist would have begun his will in the words he does

> In the name of the Almighty and Eternal God. Amen! I do most humbly render my soul to Him that gave it, and to my blessed Lord and Saviour, Christ Jesus; and my body to the earth to be buried.

In any case, the prince of biologists can not be accused of irreverence, far less of atheism. Harvey was the very opposite of irreligious. Once and again in his writings he alludes to divine purposes and designs. He says when he first looked at the beating heart, its movements were so tumultuous as to be comprehended by God alone. Referring to the valves in the veins, he says they were so placed by divine purpose.

William Harvey died at Roehampton in Surrey, on the third of

June, 1657. From the only account we have of his last days, there is no question that he died of left cerebral hemorrhage, for he had aphasia and paralysis. In a death-mask made from the old bust in the church, the right eye is more closed than the left, which would agree with right-sided paresis.

He was buried on June 26 in the Harvey vault which his brother Eliab had constructed below the parish church of Hempstead only two years before. Hempstead is an ancient village seven miles southeast of Saffron Walden in Essex. The funeral was attended by the president of the College of Physicians and a deputation from the same, and by Aubrey, his biographer, who helped to place the body in the vault. Aubrey says he was "lapt in lead," and on his body in great letters his name, "Doctor William Harvey." Quite a number of the members of the Harvey family were buried in these curious mortuary cases. In 1847 the late Sir B. W. Richardson, on visiting the church, found the window of the vault broken and rain gaining access to the floor: the case containing Harvey's remains was cracked and a frog jumped out of it. Richardson rightly thought that this state of things was not as it should be. In 1878 the conditions were still worse; by aid of magnesium light and a mirror he managed to reflect some light into the case and convinced himself that some remains were there. Accordingly he obtained permission from Dean Stanley to have the shell reburied under a glass slab in the pavement of Westminster Abbey beside the grave of John Hunter, Hunter his descendant, not according to the flesh, but according to the spirit of a seeker after truth. Owing to the Dean's death, the project fell through. In 1882 the tower of the church fell through the roof, and so Richardson thought the sooner that Harvey's remains were put into a place of safety the better. At the expense of the College of Physicians, a beautiful sarcophagus of white Sicilian marble was built in the north transept of the church just above the vault, and on St. Luke's Day, 1883, Richardson and seven other Fellows placed the old shell in the sarcophagus which bears this inscription.

The remains of Harvey, the discoverer of the circulation of the blood, were reverently placed in this sarcophagus in 1883 by the Royal College of Physicians of London.

On the wall of the chapel close to the tomb there is a bust above the family coat-of-arms and a Latin inscription, a translation of which I shall give here, as it is in no account of Harvey's life and because it is always interesting to know what the competent contemporary opinion of a man was. The translation I owe to the kindness of my learned friend, Professor Wallace Lindsay, M.A., LL.D., of the University of St. Andrews:

William Harvey, to whose honorable name all academies rise up out of respect, who was the first after many thousand years to discover the daily move-

ment of the blood, and so brought health to the world and immortality to himself, who was the only one to free from false philosophy the origin and generation of animals, to whom the human race owes its acquirements of knowledge, to whom Medicine owes its very existence, chief Physician and friend of their Serene Highnesses James and Charles, Monarchs of the British Isles, a diligent and highly successful Professor of Anatomy and Surgery at the College of Medicine at London; for them he built a famous Library and endowed it and enriched it with his own patrimony. Finally after triumphal exertions in observation, healing and discovery, after various statues had been erected to him at home and abroad, when he had traversed the full circle of his life, a teacher of Medicine and of medical men, he died childless on June 3 in the year of grace 1657, in the eightieth year of his age, full of years and fame.

The Royal College of Physicians, of which he had been president in 1654, benefited greatly under Harvey's will, but it had already found him a noble benefactor during his life. In 1651 he had built a library and a museum for the college at Amen Corner; and, as acknowledgment, the Fellows erected a statue of him in their hall which was destroyed in the fire of London. Harvey assigned to the college his patrimonial estate of Burmarsh in Kent, a donation which provided the salary of the librarian and keeper of the museum. He also instituted an annual oration in praise of the benefactors of the college, and provided for an honorarium to the orator and for the expenses of an annual banquet. The Harveian oration has been delivered each year since that time; it is considered one of the greatest honors that can be paid to a Fellow to appoint him Harveian orator.

Curiously enough, there is no biography of Harvey that can be called authoritative. The only contemporary account of him, for it can not be called a biography, is by his friend, John Aubrey, the antiquary, the same Aubrey who has left us *some* facts about Shakespeare. This is an unsatisfactory, slight, gossiping account written by a medical layman. Quite the best life of Harvey is from the pen of Mr. D'Arcy Power, F.S.A., F.R.C.S., in the "Masters of Medicine" series. To it I have been indebted for many facts. Although, therefore we have no complete contemporary biography of the greatest epoch-maker in medicine, we can glean enough to show us in what esteem he was held by certain very different kinds of persons. Hobbes, of Malmesbury, placed him alongside Copernicus, Galileo and Kepler, and declared "he first gave the true science of the human body." In another book Hobbes wrote of Harvey, as "the only man I know that, conquering envy, hath established a new doctrine in his life time."

The highly acute and ingenious natural philosopher Robert Hooke, F.R.S., mentions Harvey's discoveries alongside those of Pecquet, Bartholinus, Willis and Glisson. The great Descartes in one of his letters writes of Harvey, thus:

> As to the circulation of the blood, *there* he has his triumph, and the honor of first discovering it, for which medicine owes him much.

Thomas Bartholinus, of Copenhagen, said:

The English physician to whom belongs the honor of having first shown that the course of the blood is nothing less than a kind of perpetual movement in a circle.

Elsewhere Bartholinus declared:

To have had the glory of discovering the movements of the heart and blood was enough for one man.

Haller, a very learned and discriminating authority, called the De Motu, "libellus aureus."

I must refrain from any references to allusions to Harvey in contemporary English verse: both Dryden and Cowley have lines on him, but they are very poor stuff indeed.

Nor have we to-night time to discuss the large question of the claims of the Italian naturalist, Cæsalpino, to the honor of the discovery, important as this undoubtedly is. Harvey's life and work is rather too large a topic for one evening hour, but perhaps enough has been said to let us have *some* idea of both.

The "De Motu" is the greatest single essay on a biological or medical subject ever given to the world. It ranks on an equality with those other epoch-making monographs of Jenner, Schwann, Darwin, Simpson, Pasteur and Lister. Harvey did for physiology what Newton did for astronomy: gave a generalization which put many isolated facts into their places. It revealed an astonishing unity of plan amid manifold diversities of type. So grand was the simplicity of the mechanism of the circulation that that alone was enough to tell him he had attained to a great truth. He saw the one design everywhere, in the heart of the chick as yet unhatched, in the humblest insect, in the stately deer in the Royal park at Windsor. Harvey's work was epoch-making, because he broke with tradition and because it was founded on an experimental basis. Although his name is not in the original charter-book of the Royal Society (it could not be as its date is 1664), all Harvey's intimate friends were Fellows, and there is no possible doubt but that Harvey *would* have been in the Royal Society, as he was in that earlier unorganized nucleus of it at Oxford. Though a professional anatomist, he studied structures to discover their uses. Just as one of Galen's books is the "De usu partium," so Harvey's masterpiece is "Concerning the Motion and Uses of the Heart and Arteries." Harvey is always physiologically-minded. Harvey was a great man in an age that produced many great men; he was not dwarfed by his contemporaries because they too were great. What Shakespeare and Molière are to the drama, what Milton is to poetry, Bacon to prose, Bunyan to allegory, Murillo and Rembrandt to painting, Wren to architecture, Grotius to international law and theology, Galileo and Newton to terrestrial and celestial physics (and these, all his contemporaries, are masters), such is William Harvey in the realm of the knowledge of the most important system in the bodies of living beings.

GREAT EROSIONAL WORK OF WINDS

By Dr. CHARLES R. KEYES
DES MOINES, IA.

AS in the eighteenth century marine planation was one of the notable discoveries in earth-study, and as in the last century the theory of general peneplanation through stream-corrasion was one of the grander conceptions of the age, so the recognition of desert wind-scour as the principal among erosional agencies seems destined to take its place among the first half-dozen great and novel thoughts which shall especially distinguish geologic science of the twentieth century. Under conditions of arid climate, by which more than one half of the land-surface of our globe is profoundly influenced, eolian erosion appears to become, as recently aptly stated, more potent than stream-corrasion, more constant than the washings of the rains, more extensive and persistent than the encroachments of the sea. Both as a sculpturing power and as a sedimentative agent the wind is thus in every way comparable to erosion and deposition by river and by ocean.

That it is possible for the universal disintegration of the rocks to go on by means of insolation instead of through ordinary chemical decay, that general and rapid exportation of rock-waste takes place through the agency of the winds instead of through the movement of waters, and that on the land deposition of wind-borne dusts in terranes

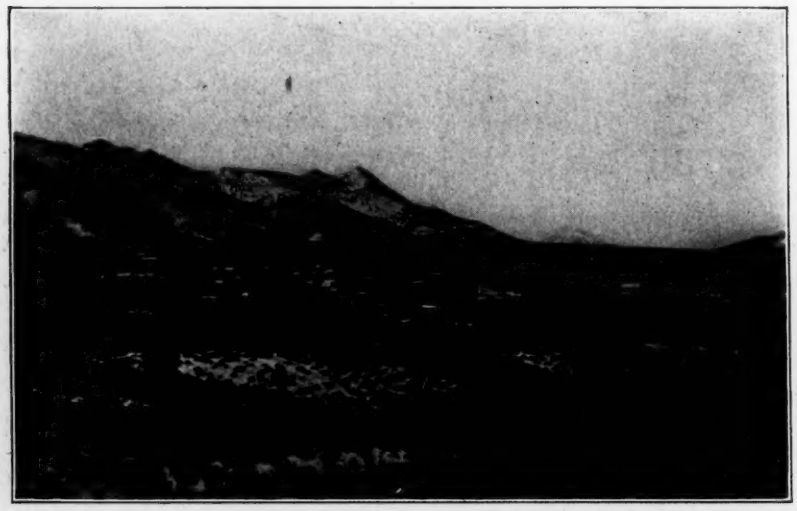

FIG. 1. TYPICAL ENISLED LANDSCAPE, NEAR WONDER, NEVADA; displaying differential effects of general wind erosion.

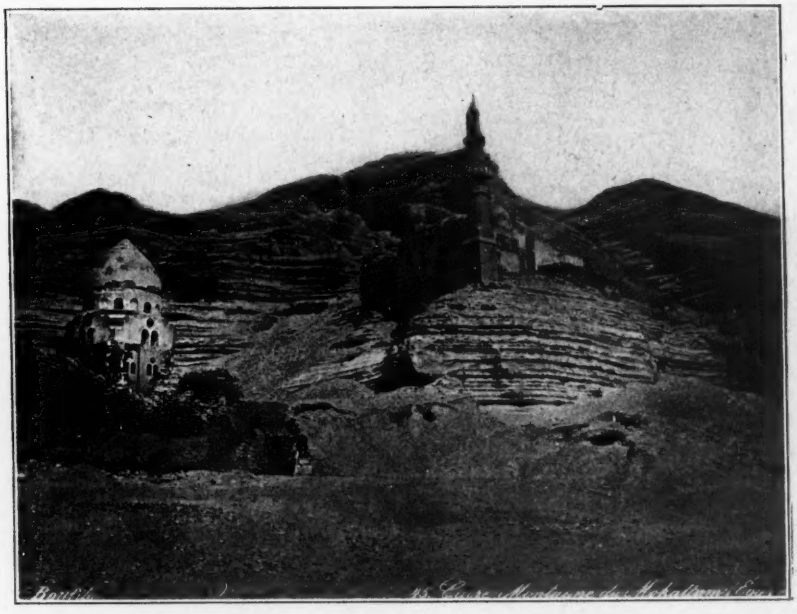

FIG. 2. WIND-GRAVED CLIFFS OF THE MOKATTAM HILLS; on the borders of the Arabian desert opposite Cairo, Egypt.

as mighty as any swept into the seas by streams or laid down on the floor of the ocean, are new and important generalizations belonging distinctly to the first lenstrum of our new century.

Prior to the year 1900 wind-action had been always regarded as merely one of the minor geologic agents of erosion—a mere idler in its manifestations, and a denuding power at all times negligible. That its real rôle in geologic economy had been so long so completely overlooked

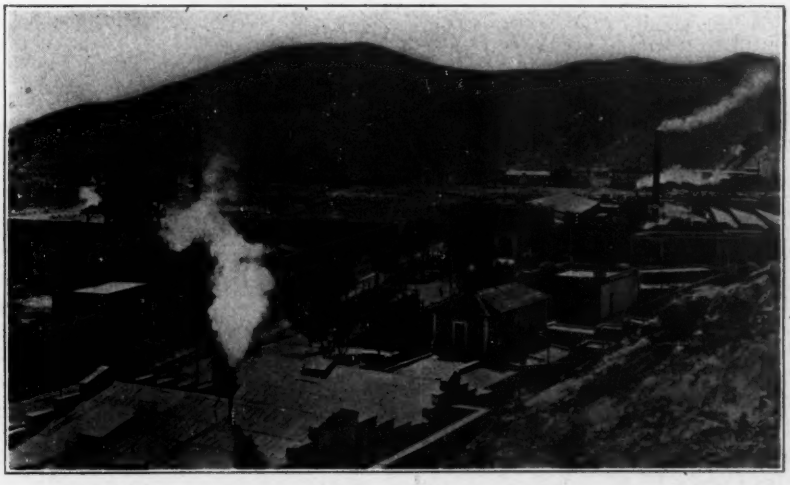

FIG. 3. SHARP MEETING OF HARD MOUNTAIN ROCK AND SOFT PLAINS STRATA; Torreon, Mexico—a characteristic feature of regional eolation.

FIG. 4. INFANTILE STAGE OF A VOLCANO IN HIGH DESERT OF WESTERN NEW MEXICO; contest of two mightiest of earth powers to impress the local landscape.

appears to be due to the recency and enthusiasm with which by the scientific world the great law of the base-level of erosion had been received and to the vast dynamic possibilities which it had opened up.

Scant indeed is the attention given in the text-books on earth-history to the geologic effects of wind-action. A good and concise summary of our prevailing notions on the subject a decade ago is given by Udden. The great significance and value of the newer generalization lies not alone in the recognition of the geologic potency of wind-power as an agency of erosion, or as a means of forming such vast continental deposits as the loess, but of its tremendous efficiency as a general or regional denuding force. In far-reaching importance it compares favorably with the enunciation of the glacial theory of the last century.

It has long been the custom not only to treat the subject of general land-sculpturing independently of climatic considerations, but as if the molding of all landscape features was controlled by the same laws. The fertility of suggestion arising from the conception of a definite cycle of development through which all land-forms must pass has tended to exaggerate the evolutionary aspects of the theme at the expense of the genetic means by which the physiographic changes have taken place. Even the latest and most authoritative treatise on physical geography has premised the same derivation of physiognomy for the glacial Alps and the arid-high plateaux of western America, for the forest-clad Appalachians and the barren South African veldt, for the jungle-matted eastern Andes and the desert Australian interior. Ordinary stream-corrasion is made to account for all. Rain is regarded as the universal and sole graving-tool of land-sculpturing.

A full comprehension of the pregnant idea that wind-action under the favorable physical conditions imposed by arid climate is a general erosional agent may be said to date from the year 1904—the time of the appearance of Passarge's brief but quite remarkable essay on "Die Inselberglandschaften im tropischen Afrika." In various parts of the world during the decade previous the conception had in one way or another begun to assume form. The Trans-Caspian region had already furnished some facts bearing upon the new generalization. The vast deserts of the Dark Continent had supplied others. Our American arid lands had brought forth a host of still different suggestions. Indeed, as a definite working hypothesis the general scheme appears to have been first successfully formulated and applied in the great dry region of our own Southwest.

Whether first definitely outlined by American on the Girghiz steppes, by German on the South African plateau, or by Yankee on the Mexican tableland, it is certain that, as McGee astutely observes, the satisfactory disposal of the rock-waste of the desert by prodigious wind exportation furnishes the missing link to a rational explanation of all the long puzzling phenomena presented by arid regions throughout the world.

FIG. 5. ORTIZ LACCOLITH, 5,000 feet high, unearthed from soft deposits 10,000 feet thick, by wind erosion mainly.

The distinctive feature of this great new conception of regional eolation is that under the favorable climatic conditions of aridity such as effect more than one half of the entire land-surface of our globe wind-scour is the chief agency of provincial lowering and leveling, far more rapid and efficacious than any general work by rain, river or ocean. To it are ascribed all the larger lineaments characteristic of arid lands. By it are graved the majority of desert details. It is the dominant sculpturing power in all excessively dry regions.

In a district undisturbed by mountain-making forces even plains are produced, smoother than any peneplain possibly can be, and yet

FIG. 6. PANORAMA OF LAVA-WASTE ON EDGE OF NEW MEXICAN DESERT; viewed from point 8,000 feet above plain; central butte 15 miles distant.

standing at a level high above that of the sea; such are the Kalihari and elevated South African veldt, recently so graphically described by Passarge, Bornhardt and others. Elsewhere, when open-patterned orogenic structure prevails, broad valleys and lofty flat-topped highlands persist, as in Turkestan, lately noted by Davis, Huntington and Friederichsen. Our own southwestern country, with its close-patterned structure, presents still other phases, remarkable as the most perfect of all typical Inselberglandschaften.

Singularly enough, the great law of the base-level of erosion, the most useful in all geologic science, had its birth under the cloudless skies of desiccated lands where in reality no vestige of its operations is discernible. The grand generalization applies strictly to land-surfaces under humid climates. Doubtless for this reason it is that none of our numerous government experts, in their fifty years' experience covering every part of the vast arid domains of the West, failed to perceive any-

FIG. 7. EXPANSE OF VAST DUNES IN HUECO BOLSON; the white sands of purest gypsum are blown out of great desiccating salinas.

thing of the potency of wind-action in the general leveling and lowering of the country. Of late years others who have traversed this field have caught occasional glimpses of deflative activity. Spurr notes certain minor aspects of it in the intermont basins of Nevada. Davis mentions others in Utah and Arizona. Cross calls attention to some notable phenomena in the San Juan district of southwestern Colorado that he mainly ascribes to wind-action. Hill describes still other features in northern Mexico. Free summarizes the literature on the action of the wind in the formation of soils. In none of these records of observation is the great principle of regional eolation recognized or even suggested. Through all of them the influence of the idea of peneplanation by water is overpowering.

No phase of land-sculpturing by water explains the peculiarities of desert relief. Where in humid lands are there such vast and even surfaces as the intermont plains of arid regions? Where under conditions of moist climate do such lofty mountains stand out so isolated as in our southwestern country—ideal monadnocks only theoretically and faintly suggested elsewhere? Where but in a dry climate does entire absence of foothills characterize the mountain ranges? Towering desert eminences rise out of elimitable expanse of level plain as volcanic isles jut from the sea. Plain meets mountain as sharply as the strand-line of the ocean. The rock-floor of the desert is often a plain itself worn out on the beveled edges of the strata beneath. The remarkable plateau-plains clearly represent former plains-levels. The soil-mantle is gen-

erally thin and gravelless; and all surface materials are transported. There is almost total absence of distinct waterways in the broad valleys. None of these relief characters bespeak of water-action of any kind. They all bear testimony of some erosive agency other than the one with which most of us are most familiar. Water can not do such geologic work. It seems to be a great advance in earth-study to be able at last to account satisfactorily for the formation of all those wonderful expressions on the face of the desert that have been so long so manifestly little understood or misinterpreted.

As in the case of ordinary general erosion, there are involved the three major processes of rock-weathering, transportation of rock-waste, and deposition of sediments, so in eolation there are the three corresponding phases termed insolation, deflation and aeroposition. Rock-weathering in the desert is peculiar in that there is practically no chemical decay going on at the surface. The destruction of rock-masses is accomplished by means of a process known as insolation—a constant flaking-off of rock fragments due to the great diurnal range of temperature so prevalent in dry climates.

The movement and exportation of fine rock-waste through deflation

FIG. 8. DESOLATE MAIN STREET IN MEXICAN ADOBE TOWN IN THE DESERT.

is now measurable to something of its true proportions. A "sand-storm" or "dust-storm" is really a strong desert air-current two or three hundred miles in width instead of a mile wide as in the case of the largest rivers, running forty miles an hour instead of three or four miles, and sweeping along a thousand times as much sedimentative materials. Only by such comparison is the enormous erosive potency of deflative action fully comprehended.

Wind-formed deposits are mainly laid down far outside the confines of deserts—in the moist verdure-clad lands, or in the sea. Their magnitude is very great, as the enormous loess formations, the vast expanses of black soils of the steppes and prairies, and the extensive adobe clays

FIG. 9. AN OASIS IN AN AMERICAN DESERT (SOUTHERN NEW MEXICO).

of many parts of the world amply attest. Continental deposits of this origin are just beginning to receive from scientists the attention which they merit.

The law of regional eolation will rank high among modern geological discoveries. What William Smith's discovery of characteristic fossils for identifying geologic terranes was to stratigraphy and historical geology, what Bunsen's theory of magmatic differentiation was to modern petrology, what Agassiz's hypothesis of continental glaciation was to recent geologic history, and what Powell's law of the base-level of erosion was to physiography of to-day, so the general theory of deflation, or regional eolation, is to the sciences of desert landscape sculpturing, and the formation of continental deposits as vast as any laid down on ocean borders. The theory adequately explains a grander host of

perplexing phenomena concerning the larger features of earth than any one of the great themes mentioned and perhaps more than all of them combined. It projects the imagination backward to the beginnings of geologic history; and it carries it forward to the end of time. In the lineaments of our dead moon it may be we behold the final effect of eolic powers.

Although perhaps not wholly the unaided work of any one man or group of men, the generalization of regional eolation is first distinctively American in origin. As such it seems not too much to say that it is allotted to stand as one of the far-reaching achievements of our century. It is doubtless the last of the great discoveries in geologic science to be attained by purely observational methods. The future advancements in earth-study must be quantitative instead of qualitative in character. They must be the direct outcome of mathematical investigation, of the rigid application of the new physico-chemical laws, and of the complete evolution which the discovery of radio-activity has imposed.

This, then, is briefly a statement of the theory of regional eolation.

HOSPITALS, THEIR ORIGIN AND EVOLUTION

By JOHN FOOTE, M.D.

WASHINGTON, D. C.

THE story of the birth and evolution of the hospital is a record of the conquest of barbarism by civilization and of the triumph of Christian altruism over the selfishness of the pagan ideal. Bargaining, trading, warring, the nations of the earth have struggled upward along the difficult highway of achievement, making slow but certain progress in the betterment of humanity. Always this approach toward the ideal has been characterized by an increased interest in the welfare of the public as opposed to the individual, and exemplified in unselfish efforts to befriend the sick and friendless.

No better index, therefore, of the progress of any nation in ethics and altruism can be obtained than a report of its work in the building and management of hospitals.

In its origin the word *hospital* comes from early Christian days when it was used to designate a place where strangers and visitors were received and cared for. Whether or not hospitals proper existed in pre-Christian time is a much-debated question. The fact has been established that the Egyptians studied medicine and that the sick were brought to their temples to be healed by the priests. To some extent this practise was observed by the Greeks and by the Romans in their temples of Æsculapius.

There is certain evidence of the existence in pagan Rome of *Valetudinaria,* or dispensaries, for sick soldiers and slaves; but of the existence of hospitals proper, houses of refuge for the poor and the ill, we have no proof. Something more than mere civilization was necessary for the establishment of these tokens of man's regard for his fellow man.

In India, a country whose ancient moral code was less pagan, if not more Christian, than that of either Greece or Rome, hospitals for men and animals are described by two early Chinese explorers. Prescott states that hospitals existed in Mexico before the Conquest, but his documentary proof is indefinite. Gaelic literature is rich in traditions concerning the House of Sorrow, a hospital for the wounded of the Red Branch Knights who lived about 300 B.C. at Tara, the palace of the kings of the heroic age of Ireland. But on sifting the evidence, we are justified in assuming that the claim of the pre-Christian hospital rests largely on tradition, while proof is abundant that these institutions were liberally encourgaed by the Christian Church.

There are many allusions in the New Testament concerning the healing of the sick, and Christ himself commanded his disciples to care for the ill and indigent. The practise of hospitality was enjoined as a virtue upon the early Christians; bishops, presbyters and deacons were especially obliged to practise this virtue and references to it are found in the Acts and most of the early commentaries. These documents tell us that in the bishop's house was a room set apart for the use of poor and ill travelers, designated as the *hospitalium,* or rest room. Harnack[1] states that the bishop was also required to act as a physician. In this *hospitaliun,* therefore, in name as well as in function, we find the legitimate, though remote, ancestor of the modern hospital.

The many epidemics occurring in the Roman empire, as the epidemic of Carthage in A.D. 252, described by St. Cyprian,[2] gave those who would care for the sick abundant employment. Many a wealthier Christian imitated the bishop's good example and established a *hospitalium* in his own house. But, hunted and persecuted as the sect was, there could be no organization of this work; their efforts must remain desultory and scattered until the ban was removed. So it is that the advent of the public hospital comes after the reign of Constantine, when a great increase in the number of Christians and the spread of poverty had made adequate individual effort by the bishops difficult if not impossible.[3]

More than one writer has asserted that hospitals originated from three supposedly antagonistic influences, religion, war and science. This statement is not true for several reasons, but chiefly because history is opposed to it. There was plenty of fighting in pre-Christian days, but hospitals did not result from it. The Greeks had far more scientific knowledge than the Goths, yet the former did not build hospitals, while the latter did. Indeed, the real situation is outlined if we say that in the social ebullition produced among the nations of Europe by the introduction of Christianity, hospitals were the distillate and war and science the by-products.

The Christianity of the Lombards, the Goths and the Franks was a militant one. Scarcely had Clovis, the Frankish king, renounced his old gods than he commenced a holy war upon his unorthodox neighbors with the twofold object of converting them and obtaining dominion over their lands. In the dream of empire of the first great Charles the sword and the cross were close companions. Yet these early Frankish monarchs in the intervals between their wars were earnest in the building of hospitals. Long indeed after the hospital made its

[1] Harnack, "Medicinisches aus d. altesten Kirchengesch," in "Texte u. Untersuchungen," VIII., Leipzig, 1892.

[2] Cyprian, "De Mortalitate," XIV., in "Patres Latinæ" of Migne, IV., 591–593.

[3] Rom. XII., Heb. XIII., Peter IV., John III. Ep.

appearance came the university—so long, in fact, that the statement that the origin of the hospital owed much, if anything, to science is disproved chronologically. And this, too, without in the least minimizing the influence of the great medieval schools, such as Salerno and Montpellier, upon the hospitals of the middle ages.

But now to consider in brief detail the hospitals of early Christian era. We must first give our attention to the east, where the conversion of Constantine gave an impetus to the spread of Christian religion. Ratsinger[4] asserts that a hospital was established at Constantinople by St. Zoticus during the reign of the first Christian emperor, but his authority for this statement is mythical. We have, however, documentary proof in the writings of St. Gregory,[5] of Nazianus—whose brother, by the way, was a physician—of the establishment of a hospital by St. Basil at Cæsarea, in Cappadocia (A.D. 369).

According to Gregory, it was a veritable city with streets separating pavilions for various diseases and also workshops, industrial schools, convalescent homes and residences for attendants, nurses and physicians.

Indeed, the plan seems not unlike our most modern pavilion system; the ancient writer waxes enthusiastic in his praise of it, declaring it to be "a heaven upon earth."

Alexandria boasted a hospital in 610, founded by St. John the Almsgiver, and at about this same time Bishop Brassianus established one at Ephesus. Contemporaneous was the foundation in Constantinople of three hospitals, one by St. John Chrysostom, one by St. Pulcheria, sister of the Emperor Theodosius II., and one by St. Sampson. Thirty-five hospitals were erected in this one eastern city alone before the tenth century, according to the Constantinopolis Christiana of Du Cange. An orphanotrophium was established in the tenth century by Alexis I., and the Hospital of the Forty Martyrs by Isum II. in the eleventh century. Such was the influence of these Eastern institutions that we find their Greek terminology influencing the names of early institutions of the west. In all the writings of later days concerning hospitals a house for sick people is called a "noscomium," for foundlings a "orphanotrophium," etc. Perhaps one of the best proofs we have of the activity of the Christians in hospital building is the fact that the Emperor Julian, called the Apostate, decreed that hospitals should be built to offset the influence of similar institutions which the Christians had inaugurated.

St. Jerome[6] tells us of the hospital builded by Fabiola in Rome during the fifth century. Fabiola, a wealthy Roman lady, is probably our first Christian philanthropist. Pope Symmachus (495–514) built

[4] Ratsinger, "Gesch. d. kirchlichen Armenpflege" (Freiburg, 1884).
[5] "Patres," Migne.
[6] "Patres Lat.," Migne.

three hospitals in Rome during his pontificate, and these were maintained and additional ones built by his successors. But Stephen II. surpassed his predecessors in the eighth century by restoring four ancient institutions and building three new ones.

The Arabs, speedily changing from a barbaric army to a cultivated and civilized people through their contact with Greek thought in the countries conquered by them, were not long in proving their enlightenment by the standard of hospital building. The first Arabian hospital was built at Damascus A.D. 707 by the Caliph el Welid. Virtually the real rise of Arabian science came with the accession to power of the Abbasides (A.D. 750). The Arab by this time was a mixed nation, in which the Persian element seemed to predominate. Hospitals under medical supervision were not uncommon, although infirmaries predominated. Nuburger states that infirmaries existed in no less than fourteen cities, including Bagdad, Antioch, Jericho, Medina, Mecca—in short, throughout the entire empire. The part played by pilgrimages to places of devotion among Christian nations in the evolution of the hospital was perhaps even more pronounced among the followers of Mohammed. Clinical teaching was done in several of the large hospitals of Damascus, special attention being given to medicine and diseases of the eye. The hospital, mosque and orphanage founded by al Munsur in the thirteenth century was one of the most notable Arabian charitable institutions and is said to have had a staff of forty-two physicians.

Probably the earliest hospital in France was the "Xenodochium" for pilgrims, established by King Childebert in the sixth century. The practise of making pilgrimages to the shrines and holy places was a custom of the pious coming more and more into vogue, and the monarch's action was a much-needed charity to the sick and weary travelers. The Council of Orleans (549) gave this establishment hearty approval.

Many hospitals arose in France during this and the succeeding century. For at just this period the Franklish empire, more than any other European country, was slowly tending toward the conditions which made it eventually a nation of city dwellers, dimly foreshadowing what came later with the establishment of industries, the foundation of guilds and the influence of trade and commerce on national life. At Autin, at Athis, at Paris, Arles and Rheims, we have records of the establishment of hospitals by kings, nobles and churchmen. The oldest hospital in the world still enduring, the famous Hôtel Dieu, is attributed to Landry, Bishop of Paris, and its origin has been variously placed between A.D. 660 and 800. Lallemand's "Histoire de la Charité"[1] finds the first extant written mention of it in a document of 829. This began as a cathedral hospital, and was one of a group of institutions growing up about the old churches, which, developing into small com-

[1] "L'Histoire de la Charité," II., 112, Paris, 1902.

munities, formed the nucleus of many of the larger cities of the feudal period. Undoubtedly of much earlier origin was the Hospital Scothorum, which was built on the continent at a remote period by missionary Irish monks. This was destroyed and later was restored by order of the Council of Meux (A.D. 845). These were probably the same monks who founded the monasteries of Bobbio and St. Gall, and carried the art of illuminating manuscripts as well as the gospel itself to the semi-barbarous peoples beyond the Alps.

The idea of medical missionary work is not a new, but a very old, idea. Barbarous Europe was converted by medical missionaries; practically all of the monasteries of the monks of the west did hospital work.

This monastic influence reached its zenith in the tenth century, and the most famous hospital-monastery of that day was the Benedictine abbey of Cluny, founded in 910, and commanding not only a local reputation, but famed through Italy and France.

Originally each monastery had its infirmary for inmates, and this under the laws of hospitality was open to sick travelers. Before long the crying need of medical aid extended the ministrations of the infirmary to the people of the neighborhood, or to any who might seek it. The monastery was the repository of medical as well as all other written knowledge of that period, and it has been proved that among the profane authors copied by the monks in their scriptoria were some of the classical authors on medicine.

We must not imagine that the cathedral hospital languished during the preponderance of monastic medicine; according to Virchow, 155 hospitals were founded in Germany alone from 1207 to 1577. With the growing importance of the hospital it is no surprise to find religious communities springing up whose chief and surpassing occupation was to be the care of the sick. The first of these was organized in Siena, a cradle of Italian genius, during the ninth century. Soror, the founder of the hospital of Santa Maria de la Scala, drew up the rules for its administration with his own hands. The management was largely in the hands of citizens, subject to the bishop's control. Many such communities were established in Italy and lived under the rule of St. Augustine.

From this time onward the religious orders strongly influenced hospital development. In the twelfth century the Beguines and Beghards were hospital orders which flourished especially throughout Belgium, France and Germany, while the Alexians and Antonines established and managed hospitals in various parts of Italy as well. Leprosy following in the wake of the crusades, special communities were formed to care for lepers. Thousands of leper houses arose in all parts of Europe—it is estimated that 2,000 existed in Germany alone. The plague was eventually stamped out, an achievement in a public health

campaign which would do credit to a much more enlightened age. Special communities also isolated and nursed cases of erysipelas known as St. Anthony's fire, St. Francis's fire, etc. But the most important event in the history of hospitals in the period we must now consider, the middle ages, was the foundation of the order of the Holy Ghost, resulting, as it did, in a golden age of hospital building extending from the thirteenth to the fifteenth century and not equaled again till the hospital renaissance of the nineteenth century.

In the middle of the twelfth century Guy of Montpellier established the Hospital of the Holy Ghost in the city of his name. Montpellier was at that time the medical mecca of Europe and attracted students from remote cities. Not only the reputation of the hospital, but the order itself spread rapidly through France, building and managing hospitals.

Innocent III., the great militant pope, who did so much to strengthen the temporal power of the pontiff, had recently builded a hospital in Rome. It was characteristic of his genius that he foresaw the need of hospitals and the great work they might accomplish. He determined to promote their building not only in Rome and the Papal states, but also wherever his influence extended. To this end he summoned Guy to Rome and gave him charge of the new hospital of Santo Spirito. Visitors from all parts of the world were shown this hospital and encouraged to establish similar ones in their own communities. The object lesson served such a useful purpose that very soon hospitals were arising in every city of importance in Europe. The "Benificienza Romana" of Querini gives the names of thirty hospitals founded in Rome itself from the eleventh to the fifteenth century.

The part played by the crusades and the military and hospital orders in the evolution of hospitals can not be overlooked. Disease and pestilence were more potent in defeating the crusaders than the swords of the Saracens, and the military hospital orders found abundant employment. The Knights of St. John, an order founded to care for the sick and wounded, maintained after the conquest a hospital at Jerusalem said to accommodate 2,000 patients. Many priories were established in various parts of Europe while the order flourished. At first the knights acted as nurses and physicians to the sick crusaders; the military features of the order developed later. The organization became very rich and powerful in the course of time, and, swerving from its original purpose, degenerated and finally fell into disrepute. The Teutonic order, an organization of German knights banded together for labor in the Holy Land, did splendid work in building and managing hospitals. Many German hospitals were under its control and, unlike the Knights of St. John, it adhered closely to its original purpose. War and consequent financial reverses caused its dismemberment.

With all these institutions builded by popes, bishops, monks and crusaders, it would seem too soon to look for city hospitals. Yet very many such arose after the first crusade. Eastern commerce flowing in the wake of the crusaders, an increased national wealth and an increased population furnished both the resources for and the need of municipal and privately endowed institutions. Privately endowed hospitals are found first in Italy, and during the twelfth century Monza had three and Milan eleven such institutions. During the fourteenth century Florence had thirty private foundations. Some of the founders were notable people; the Santa Maria Annunziata in Florence was founded by Falco Portinari, father of Dante's Beatrice, and one of the Milan institutions by the Duke Francesco Sforza. In Germany during this period fifty-two city hospitals existed, sixteen being situated in Cologne, the remainder in about thirty smaller cities, the names of which are enumerated by Virchow.[8]

Various abuses began to creep into hospital administration during this period of prosperity which later caused trouble to ecclesiastical authorities, until some of the hospitals, while still conducted by religious orders, were placed under civil authority, the church still paying for their maintenance. In Italy, toward the end of the middle ages, this tendency grew more marked; in France it came considerably later, although the same conditions existed. It was in the fifteenth century that the Hôtel Dieu showed such gross mismanagement that the ecclesiastical chapter of Notre Dame, feeling its inefficiency to cope with the situation, requested the civil authorities to take over the hospital (April, 1505). It was thereafter managed by a board of eight trustees.

The ancient hospitals in Great Britain and France were for a long time under the control of the monastic orders. According to Harduin, a large hospital was founded at St. Albans in A.D. 864. Alcuin, the great scholar, who afterwards was called to the court of Charlemagne to preside over the School of the Palace, wrote to the Archbishop of York (796), and urged the foundation of hospitals for the poor and for pilgrims. The oldest hospital existing to-day as a foundation is St. Bartholomew's in London. This was established in the twelfth century by Rahere, at one time a jester to King Henry I., who later joined a religious community and secured a grant of land near London. Until its disestablishment under Henry VIII. this was the leading London hospital. St. Thomas' hospital, founded in 1215 by Peter, bishop of Winchester, suffered a similar fate, but was reestablished by Edward VI. Among other important hospitals of London belonging to the thirteenth century were Bethlehem, which later became an insane asylum and had its name contracted to Bedlam, Christ's Hospital and the Bridewell, the latter later becoming a prison and the former a school.

[8] Virchow, "Abhandl.," Vol. II., 16. See footnote 10.

There were many other hospitals in England during the middle ages outside of London, and Dugdale in his Monasticum Anglicanum enumerates 460 and gives the charters of many of them.

Prior to the sixteenth century seventy-seven hospitals were founded in Scotland and over twice that number in Ireland. The green island gives testimony as to the existence of hospitals not only by her law-code, the Brehon laws, but also by the perpetuation of such place-names as Spidal, Spital and Hospital. The Brehon laws are specific regarding hospitals, stating that the hospital must be free from debt, must have four doors for ventilation and that a stream of water should run through the middle of the floor. Dogs, fools and scolding women must be kept away from the patient. Whoever injures another must pay for the maintenance of the injured one in the hospital or private house and also for the maintenance of the mother of the injured one, if she should be living.[9] The Knights of St. John established several priories in Ireland, the most important one being Kilmainham priory, founded in 1174 by Strongbow. The Crutched Friars or Crossbearers flourished during the twelfth century and erected many hospitals. There are records of thirteen hospitals founded from this time onward which were confiscated in the strife following the reformation. That a number of leper-houses existed is attested by documentary references as well as by place-names.

Before we pass on to the modern epoch, a consideration of the character and discipline of these medieval hospitals will be of value. With a view probably toward facilitating drainage many of these hospitals were built near a river, as the Hôtel Dieu, on the Seine; the Santo Spirito of Rome, on the Tiber; St. Francis, in Prague; on the Moldan; and Mainz, on the Rhine. Many of these early hospitals were small, especially those privately endowed, and contained only about fifteen beds; others were planned by able architects, and on a large scale. The main ward at Santo Spirito, in Rome, was 409 feet $\times$ 40; at Tonnere 260×60; at Frankford 130×40. All these hospitals had numerous windows for ventilation, and some a cupola. The interior was usually decorated with great skill and care. Says Gardner, in his history of Siena:

> The hospital at Siena constitutes almost as striking a bit of architecture as any edifice of the period and contains a magnificent set of frescoes, some of the fourteenth century, others later.

The Tonerre hospital, previously referred to, founded in 1293 by Margaret of Burgundy, sister-in-law of Louis IX., was situated between the branches of a small stream, and its ward was lighted by many large windows extending high up in the walls. A narrow gallery ran along the wall twelve feet from the floor for the regulation of ventilation

[9] Joyce, "A Social History of Ancient Ireland," London, 1903, I., 616 et sq.

through the windows and the seating of convalescent patients in the sun. The beds were separated by low, wooden partitions which were portable, making the alcoved recesses part of one large hall at will, so that when mass was celebrated in the center of the building the altar was visible from all parts of the ward.

Mr. Arthur Dillon, an architect, whose scholarly article on this hospital appeared in 1904, says of its construction:

> It was an admirable hospital in every way, and it is doubtful if we to-day surpass it. It was isolated, the ward separated from the other buildings, it had the advantage we so often lose of being one story high, and more space was afforded each patient than we can afford.

Now as to the management of these medieval hospitals. In the monasteries the superintendency was in the hands of the abbot or prior and the institution was subject to monastic rule. Even in the privately endowed hospitals practically all the hospital attendants were members of some religious community. How well these communities did their work and with what real humanitarian zeal is attested by Virchow.[10]

In the military orders, the knights called their chief administrative officer commander; in the city hospitals this officer was called magister or rector. The rector was appointed by the bishop, the municipality or the patron. Laymen were eligible for this position and in many legacies lay control was stipulated as a condition. This rector was obliged to take inventories, render and keep accounts, act as trustee for hospital property and frequently to receive and assign patients.

Usually the attendants were males, although in some hospitals male nurses had charge of surgical cases, while females conducted the obstetric and children's wards. Board and clothing were provided these nurses, but no salary. Details of dress, food and recreation were rigidly prescribed, with appropriate penalties for infractions of the rules.

Patients were admitted from all classes and beliefs without qualification, and once admitted the patient was treated as a master of the house, "quasi dominum secundum posse domus," to quote literally from the regulations. He was bathed, his ills attended to, and if a Christian was confessed by the chaplain.

The regulations specified that the sick should never be left unattended, that nurses should be on duty at all hours of the day and night, and that patients dangerously ill should be removed from public wards to a private room. Santo Maria Nuova, at Florence, had a separate ward for delirious patients, and maternity cases were attended in a separate pavilion and kept in the hospital for three weeks after delivery. Sound hygiene is evidenced in numerous regulations concerning changes of bedding, ventilation, and heating by stoves and braziers.

[10] "Gesammelte Abhandlungen aus dem Gebeite der "Offentlichen Medecin und der Seuchenlehre," von Rudolph Virchow, Berlin, 1879, tr. in "The Popes and Science," Jas. J. Walsh, Fordham University Press, 1911, pp. 256, 263.

The revenues of the hospitals were derived usually from endowments, either given as private bequests or by church authorities. In times of unusual need special taxes were levied on commodities such as oil, salt, wheat, etc. Some hospitals owned houses, farms, vineyards and even whole villages as sources of income. Various societies and guilds were also established in aid of hospitals, and frequently diocesan laws required the clergy, especially the canons of cathedrals, to contribute. The complete foundations for hospitals, as well as the establishment of beds and contributions for heating and lighting, etc., were frequently made by lay persons.

As the hospitals increased in wealth and the religious orders grew lax in their discipline various abuses arose. Inefficient supervision by ecclesiastical authorities, too many attendants, too few beds, and imposition on the hospital by malingerers were among the evils which ultimately resulted in a loss of efficiency in these institutions. In spite of these drawbacks, however, says Virchow, "we have much to learn from the calumniated middle-ages, much that we with far more abundant means can emulate for the sake of God and man as well."

Pastoral medicine predominated up to the twelfth century and medical as well as surgical treatment was administered by monks and clerics. But with the rise of the university schools of medicine—Salerno, Montpellier, Bologna and Rome—and the development of such surgeons as Wm. Salicetto or Salicet, Henry Mondeville, Lanfranc and Guy de Chauliac during the thirteenth and fourteenth centuries, clerical medical practise began to wane.

It was deemed improper that a priest should shed blood and the church discouraged the practise of surgery by clerics as well as the practise of medicine for fees. Penalties for violating these precepts were laid down at the Council of Clermont (1130), Rheims (1131) and the Second and Fourth Lateran Councils (1134–1215).

The influence of the university-trained physician and surgeon on the hospital dates from this period. More and more we find lay practitioners called to attend hospital patients. In the sixteenth century we find the lay physician's connection with the Italian hospitals to be essentially the same as that in vogue at the present day. In 1524 Henry VIII. received a letter from the rector of the Hospital of Santa Maria Nuova in Florence, answering a request for information concerning the management of that hospital. From this letter we learn that three *adstantes,* or internes, attended patients and reported on their condition daily to six visiting physicians from the city. These six visiting physicians then outlined treatment and gave directions for the care of patients. Attached to the hospital was a dispensary for ambulatory cases. This was attended by an eminent surgeon and three assistants, all of whom gave their services without charge. Lallemand in his

"Histoire de la Charité"[11] gives a list of the many drugs used, and an outline of the pharmacist's duties.

Abuses in management and the civil and religious strife following the Reformation interrupted for a time the progress of the hospital movement. Revenues were cut off and hospital organizations disestablished, especially in England and Germany. It is true that attempts were made to carry on the work by parishes and municipalities, but with indifferent success.

Luther in his letters from Italy shows that he realized the importance of hospital work and he praised the Italian hospitals for their excellence. Meanwhile, a counter-reformation within the church organization was mindful of the hospital. Vives, the humanist of Bruges (1526), made a plea for a census of the inhabitants of cities, the regulation of vagrancy and hospital economy, whereby medical attendance was made more complete and the richer institutions were obliged to share their revenues with the poorer.[12] These salutary reforms were put into practise in Belgium and later were extended by Charles V. to his entire empire. In addition the Council of Trent passed rigid ordinances concerning hospital management and placed hospitals under episcopal supervision in order to prevent abuses and loose practises in administration. With these enactments improvement soon followed, and it is worthy of note that in the hospital at Milan, founded by St. Charles Borromeo, the rules sought to prevent malingering and obliged a strict accounting of its management.

In France the control of hospitals had passed to the king. Louis XIV. founded a special hospital at Paris for invalids, convalescents and incurables, as well as the great Hospital General for the poor. It was at this time that St. Vincent de Paul began his work and established the Sisters of Charity, a community destined to be famous for its work in camp and battlefield and to exert a tremendous influence on the development of nursing and the building and management of hospitals in all parts of the world. An increasing number of communities of women's nursing orders were formed from the sixteenth century onward until to-day they practically dominate this field of endeavor.

During the reign of Louis XVI. the Hôtel Dieu showed gross mismanagement and a frightful mortality. Sometimes as many as 5,000 patients were crowded there in utter neglect and abandonment. An eminent commission, including in its membership Tenon, Lavoisier and Laplace, was appointed by the king to formulate plans for remedying existing conditions. This board reported in 1788, recommending that certain wards be abandoned and that the pavilion system as exemplified in the hospital at Plymouth, England, be adopted. But the French

[11] See 7, II., 225.

[12] Vives, J. L., "De subventione pauperum," Bruges, 1526.

revolution intervened, and the needed improvements were not made until the nineteenth century.

When we consider the growth in population and wealth of nations and vaunted increase in knowledge, we can not look upon the eighteenth century as a period fruitful in hospital progress. Many new institutions were erected, it is true, but they were inadequate to the needs of the times in many respects. Among the most important establishments of this period were, in England: Westminster (1719), Guy's (1722), St. George's (1733); in Germany: the Charité in Berlin, established by Frederick II. (1710), and the Bamburg Hospital, by Bishop Van Erthral (1789); in Austria: the famous General Hospital, founded by Joseph II. (1784). Overcrowding, the prevalence of hospital gangrene and erysipelas, and the frightful mortality in many institutions made the very name hospital synonymous in the public mind with suffering and death. Yet, in spite of all this, it is from this very period that we see the development of the idea of the hospital as a necessary adjunct to medical and surgical teaching.

The history of American hospitals begins with the hospital erected by Cortez in the City of Mexico in 1524. It was remembered by the conqueror in his bequests, is still in existence as the Hospital Jesus Nazerino, and the ducal family descended from Cortez, the Dukes of Terranova y Monteleon, still exercise their prerogative of appointing its superintendents. A decade after its establishment came the Hospital of San Lazaro, accommodating 400 patients and, in 1540, the Royal Hospital, both in the City of Mexico.

Bancroft states that the law of 1541 ordered that hospitals be established in all Spanish and Indian towns. The Council of Lima (1583) made provision for the support of hospitals, and two distinct religious orders of men were founded in Mexico for hospital work.

In Canada, the Duchess of Aiguillon founded, in 1639, the Hotel Dieu, at Sillery, afterwards transferred to Quebec. The Hôtel Dieu, in Montreal, was founded in 1664; the General Hospital at Quebec in 1693.

The first hospital in the United States territory was erected about 1663 on Manhattan Island to care for ill soldiers and negroes of the East India Co. Early in the eighteenth century pest-houses for contagious diseases were established in various towns on the Atlantic coast. A permanent hospital for these ailments was built in Boston in 1717.

One of the petitioners for the incorporation of the Pennsylvania Hospital was Benjamin Franklin. The corner stone was laid in 1755, its charter having been obtained four years previously, but the structure was not completed until 1805.

The first privately endowed hospital established in the United States was the Charity, in New Orleans, founded about 1720 by a sailor named

Louis, afterwards an officer in the company of the Indies, who left a small fortune as a foundation. It was destroyed by fire in 1779 and the new Charity Hospital, now the City Hospital, was endowed in 1780. This is now one of the most important hospitals in America and receives over 8,000 patients annually.

The oldest hospital in New York City is the New York Hospital, founded in 1770 by private subscriptions. It was allowed £800 for a period of twenty years by the Municipal Assembly. The state legislature was more generous, allowing it £4,000 annually in 1795 and increasing it in 1796 to £5,000. Bellevue originated in the infirmary attached to the New York City Alms House. It was erected on its present site in 1811. Among the most important sectarian hospitals in New York are St. Vincent's, 1849, St. Luke's, 1850, and Mt. Sinai, 1852.

Fifty-six men of Boston in 1810 addressed a circular letter concerning the establishment in that city of a hospital for the poor. Jackson, Warren, and other medical lights of the day, worked out plans, and the institution, known as the Massachusetts General Hospital, was opened in 1821.

Of existing Baltimore institutions, St. Joseph's was established by the Sisters of St. Joseph in 1864; the Hebrew Hospital in 1867. The Johns Hopkins Hospital, chartered in 1867, was opened in 1889.

The District of Columbia had four hospitals during the cholera epidemic of 1832. The Washington Infirmary received congressional aid and it was proposed to enlarge it into a hospital, but it was burned during the Civil War. The Government Hospital for the Insane was established in 1852 to care for insane cases. Providence Hospital was established in 1861, largely through the efforts of Dr. Toner. Freedman's Hospital was opened in 1862 and Columbia Hospital in 1866. During the war sixty military hospitals were located in Washington and in the vicinity.

In the last half century the spread of hospitals throughout the world received a marvelous impetus. The rôle of bacteriology as applied to preventive medicine, surgery and therapeutics is one that must be accorded first place in advancing modern hospital efficiency. And in this connection the part played by Virchow's teaching of cellular pathology is a factor of much importance in its influence on medical thought reflected in hospital laboratory methods.

The Franco-Prussian and our own Civil War had much to do with directing men's attention to the problem of hospital construction and military surgery. Improved technique in nursing evolved the modern training school and created a distinctly new profession. Even before Lister's time, Florence Nightingale believed that soap and water and plenty of fresh air and sunlight would lessen mortality from hospital

gangrene. Pastor Fleidner, with his training school at Kaiserworth, and the Sisters of Charity in Paris and at the great General Hospital in Vienna, had practised, if they had not preached, this doctrine for a long time. It remained for the Crimean War and the dramatic demonstration of her doctrine by Miss Nightingale to convince the profession at large and the public. How it was accomplished is an oft-told tale. The later teaching of bacteriology in medical schools confirmed the claims for hospital cleanliness; hospital gangrene and epidemic erysipelas have disappeared.

Now is the golden age of the hospital; we need no statistics to convince us of this. Every American community of any size has not only a hospital, but a training school, and the old public distrust of the institution is on the wane with the improvement in methods and administration. To-day the patient approaches it with confidence instead of apprehension, with alacrity instead of with reluctance, and with the hope of life rather than with the fear of death.

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THE NEW OPTIMISM

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WE may distinguish three stages in the development of optimism. There was first the old *a priori* optimism of St. Augustine and Leibniz. One hears no more of this now. You may prove from the good intentions of the Creator that this world *must be* the best possible one, but the whole argument rests upon presuppositions that have less weight than formerly. Browning, when he cries, "God's in his heaven, all's right with the world," fails likewise to convince us. We prefer to look about the world and in so doing we have little difficulty in seeing many things that are *not* right.

Then, there is a second kind of optimism which follows the opposite method, the inductive, and arrives at the conclusion that the world is good and beautiful and full of happiness. It may not, indeed, be the best possible world, but it is good and fair and perhaps growing better and fairer. This is the natural, buoyant, hopeful attitude of the normal, healthy individual who enjoys his food, his sleep, his work and his play and who delights to say with Ruskin,

> There really is no such thing as bad weather, only different kinds of good weather.

Of this class are the sane and helpful writings of Sir John Lubbock or the exultant songs of Walt Whitman, which refresh us with the optimism of youth, health and springtime. Dickens, likewise, compels us to a bright view of things by his contagious good cheer. Life can not be so very bad as long as there is a tavern near by with a pot of ale and a juicy joint.

Critics may call this the shallow optimism of the eupeptic man, but it is better and more natural than the dismal croakings of Schopenhauer or the songs of sorrow of Leopardi or James Thompson. The truth is, however, that this kind of optimism, as well as that first mentioned, implies a certain blindness to the actual evils and miseries of the world, or, perhaps more often, mere ignorance of them. Our faith in it is rudely shaken by a walk through the hospitals or prisons, the smell of anesthetics, a day's journey with a country doctor, a visit to the slums, a tour of the factories and mines, or a campaign in the regular army.

But now it can not escape the careful observer that there is at the opening of this century a third kind of optimism appearing, which we may call the new optimism. It might also be called dynamic, or practical, or psychological optimism. It concerns itself with no theoretical questions as to whether this world is the best possible one or not. It

has for its motto—The world is pretty good, and we will make it better.

In the first place, this view repudiates wholly the theory of the good old times and is able to show the fallacy upon which the theory depends. In the museum at Constantinople the writer saw an inscription upon an old stone. It was by King Naram Sin of Chaldea, 3800 years B.C., and it said,

> We have fallen upon evil times
> and the world has waxed very old and wicked.
> Politics are very corrupt.
> Children are no longer respectful to their parents.

This old and ever-recurring complaint does not depend upon any actual deterioration of the times, for the times are constantly growing better. It comes usually from older people whose outlook may be biased by subjective conditions due to decaying powers and by the tendency to regard all changes as changes for the worse, the only really good times being the bright days of our own youth. It is encouraged also by the fact that, since the springs of progress are in the human mind itself, it comes about that the present times are always below the standard set by our ideals and are regarded, therefore, as bad, being compared not really with the past, but with the ideals of our constructive imagination.

Careful historical comparison leads us to the result that there has been a rather steady progress forward in all things which conduce to human happiness. Anthropologists tell us that the health of the primitive man was nothing to boast of. He had little reserve force and slight power of sustained attention. His daily sufferings from hunger and thirst, from heat and cold, from dangers from wild animals and human enemies, from constant warfare, from loss of property by theft, from sickness and accident unalleviated by surgical care, and, worst of all, from never-ceasing fear of supernatural agencies, make his life seem in comparison with ours as one of extreme hardship and unhappiness.

In the palaces of the Homeric heroes, life was far too simple to seem to us very comfortable. Apparently they had commonly no nuts or fruits to eat, no green vegetables, no butter and usually no milk, no sugar, sweets or cakes, no boiled meats, no fish, no potatoes, no relishes, perhaps not even salt in the inland places, no tea, coffee, chocolate, or tobacco. Coarse bread with roasted meat, and sometimes cheese, honey, and wine, constituted the diet of the wealthy, and what the poor had to eat it is unsafe to say. The meat, which was their chief article of food, had to be killed just before it was eaten and right on the premises. This latter circumstance, together with their perpetual sacrifices of animals to the gods, must have made their homes most untidy, to say the least.

If, rather than the Homeric heroes, we consider the most highly civilized of the ancients, namely, the Athenians of the fourth and fifth centuries B.C., their daily life seems to us hardly more attractive.

Their comforts were few and their hardships many. Their food was like that of the Homeric Greeks. Their houses were gloomy and fragile and commonly shared by domestic animals. Their streets were unpaved and filthy. There was relatively little security either of life, property or reputation. Wars were almost incessant, bringing death, dishonor or slavery to both men and women. The reign of terror which prevailed throughout the cities of Greece during the long Peloponnesian war was too terrible for detailed description.

If we were to continue this study through the days of Rome, through the middle ages, through the centuries preceding our own, we should find that there has been a pretty steady growth in all the things which we usually regard as making life worth living. If by the good old times we mean the days of Queen Bess in England, the days of our Puritan forefathers, or the more recent years of our own fathers and grandfathers, history shows us that they were uninviting. There were more and harder work, fewer comforts, less cleanliness, coarser and less varied food, less security of person and property. The good old times are therefore a myth pure and simple. The Golden Age is not in the past, but in the present.

But, some one may say, a new list of evils has come to take the place of the old ones. It is true that material comforts were lacking in the other times, but people were more hardy then. They were more robust and wholesome and less sensitive to mere inconveniences. They lived, to be sure, on brick floors and wore homespun and went often to war, but they did not consider these things as hardships. They were brave and strong-shouldered and the very battles of life were a joy to them.

Now we are weak-spirited and degenerate. Our young men are not so brave and our girls are not so modest. Our children, as Stanley Hall says,

> have limp and collapsed shoulders and chests, bilateral asymmetry, weak hearts, lungs and eyes, puny and bad voices, muddy or pallid complexions, tired ways, automatisms, dyspeptic stomachs, showing the lamentable and cumulative effects of long neglect of motor abilities.

We live in an overworked, serious and tense age. We have forgotten how to fight, to laugh, to eat, drink and be merry, but we have learned how to worry.

Furthermore, they continue, our manners and morals have deteriorated. Boodlers and bribers abound. A new bunch of grafters springs up for every one that is indicted. Jurors are fixed and voters bought and sold. Justice miscarries in our courts of law. Courts are dominated by shrewd attorneys more anxious for victory than for justice, urging delays and appeals based on mere technicalities. Then, there are the greedy trusts, the do-nothing congresses, the corruption of legislatures, jack-pot and bathroom politics, extravagance among the rich, increased frequency of divorce, smoking and drinking among women,

increased consumption of alcoholic drinks, adulteration of food, sentimentalism towards condemned criminals, yellow journals, comic supplements, and all the rest, not to speak of the wresting of lands from weak nations by strong ones, as in the case of France and Morocco, Italy and Turkey, England and the Transvaal, and the United States and Spain.

That these evils exist no optimist may deny, but that they offer any evidence that the present times are degenerate may be very seriously doubted. It may be doubted whether the young men of the olden times were any braver or had any broader shoulders, or that the girls were more modest or more virtuous. It may be doubted whether the children were of old any sounder or more robust. As regards each and all of the other indictments of the present times, it may well be doubted whether there has been any deterioration, on the whole; but rather it is probable that the farther back we go; the more weakness and deformity we shall find; the more graft, the more miscarriage of justice, the more dishonesty, the more drunkenness, the more wresting of lands from weak nations by strong ones.

The mere picturing of the evils of the present points to progress, for in times past not only were these evils present, but their presence was not much noticed. The more rare becomes crime the greater its interest for the headlines of our dailies. The muck rakers, if they had lived a few centuries ago, would have needed no rake to bring evils to the surface. No one, of course, would maintain that there has been a *uniform* progress or a *constant* decrease of evils, nor that all the sins of the present were found in the past, but on the whole the world has been getting better age by age and, sometimes, as at present, pretty fast.

But, it may be said, all this only proves that the world is getting better, not that it is intrinsically good. It might still be thoroughly bad and pessimism triumphant. With James Thompson we might still say:

> Speak not of comfort where no comfort is,
> Speak not at all: can words make foul things fair?
> Our life's a cheat, our death a black abyss.
> Hush, and be mute, envisaging despair.

As regards this question of the absolute goodness or evil of the world, the new optimism, as has already been intimated, does not greatly concern itself with it. It is rather disposed to see the good that there is and put shoulder to wheel and help it on. If, however, one were concerned with this question, it could no doubt be shown on sound psychological and biological principles that there must be a large balance of pleasure over pain wherever life forces are triumphant. But the *summum bonum* is not pleasure nor happiness, but, rather, abundance of life. Life is the key to the problem. So long as there is growth, movement, struggle, onward rush, conquest or noble defeat, there is little

pessimism. The fundamental things in our psychic life are not thought, deliberation, judgment, nor yet pleasure and pain, but rather, will, impulse, restless striving, love, aspiration, progress. It is only when these fundamental things are checked and one is forced to think and feel and examine one's feelings, that pessimism arises. Pleasures unearned are no guaranty of inward peace. As President Jordan says:

> There is no permanent state of happiness. Its joys must be won afresh with each new happy day. What we get we must earn, if it is to be really ours.

But now let us examine more carefully some of the aspects of the new optimism and some of the grounds upon which it rests. In this new philosophy of life, man is the central and determining figure. He can *make* the world good. This is a new thought in the history of optimism. We are not blind to the evils and the miseries of life, but we are conscious of a new inner force which can relieve them and redeem them. The old optimism said, Cheer up, for the world is good and beautiful. The new optimism says, Cheer up, for you can make the world good and beautiful. This view is a part of the powerful reaction which has been taking place for many years against the mechanical philosophy of life which prevailed in the latter part of the nineteenth century under the influence of Herbert Spencer and Charles Darwin. It came to be generally believed at that time that the world is merely a redistribution of matter and motion, that mechanical laws are sufficient to account for every phase of human life, including mental, moral and social phenomena, that at certain stages of organic evolution consciousness appears as a kind of by-product having no agency in the life drama itself, and that it is not necessary to take any account of it in explaining life, whether in its physiological, psychological or social aspects.

But now this disheartening philosophy is buffeted from every side, not more from the side of the psychologists and sociologists than from that of the biologists themselves. Grave doubts are cast upon the adequacy of natural selection to explain either the products or the direction of evolution, and it is now believed that there is some other determining factor which is spoken of now as consciousness, now as an initiatory psychic energy working towards definite ends, now as a vital impulse, a wellspring of progress or an original profound cosmic force. Whether consciousness itself be this original cosmic force, or whether, as some believe, it is a product of evolution, makes little difference in our problem, for human consciousness is here present in the world and it is a power which is changing not only the very face of the earth, but changing the direction of evolution itself. It would appear that consciousness has at this time reached a sort of adolescent or rapid growth stage in its development in which it has become conscious of its own powers, and this consciousness of itself increases tenfold its inherent force. We are, indeed, surrounded by mystery. Life is a puzzle and we may or

may not be able to solve it. But we find ourselves possessed of a certain power to mould our fate and to mould to a high degree the forms of nature about us. The world is plastic to the human will. In the last century, Hegel sounded this true note of human conquest, obscured as was his message by a fanciful metaphysic. Heine had the same thought when he spoke of "liberating the imprisoned energies of the human spirit." More recently, a whole group of writers, like Ibsen, for instance, have proclaimed their belief in a glad trust in nature and in human instincts. In America, William James, in his remarkable essay on "The Energies of Men" has shown the almost unlimited powers of accomplishment possessed by the human mind and the human body. In France, Bergson is showing to eager hearers from every part of the world that nature is a vital, not a mechanical, process, and that creation is something which we experience in ourselves in the freedom of action. Politically we see the same spirit exhibited in the twentieth century movements for freedom in Turkey, Portugal, Persia, Mexico, and even in China, where new and more liberal forms of government have been gained or demanded.

We may, then, say that the present epoch represents the emergence of consciousness as a determining and self-conscious factor into the progress of evolution, able in some measure to direct the evolutionary movement itself to the advantage of mankind and able to an indefinite extent to mould the forces of nature to the same end.

The directions in which this powerful conscious force is operating to further human well being are threefold.

First, it improves our material environment by the control and management of natural forces. In this direction tremendous advance is now being made in the invention of new machinery, in the discovery and utilization of new forms of energy, in improved methods of agriculture, in renewing impoverished soils by bacterial agencies, in creating new plants bearing useful fruits, in reclaiming arid lands by great systems of irrigation, in facilitating transportation by digging great canals, in making the air as well as the land and water viable, and in many other familiar ways.

Second, it is attempting with apparent success to improve the human constitution, both physical and mental, by intelligent use of the forces both of heredity and of environment. For instance, both the cause and the cure of tuberculosis have been discovered and we have hopes of eliminating entirely this cruel disease. Other diseases which in former times devastated whole regions have been practically conquered, while still others are now in process of control. Mortality has been lessened and longevity definitely increased, so that the population of nearly every country has risen, even where the birth rate has remained stationary or declined. Furthermore, consciousness itself has been made

a powerful instrument in directly enhancing human health and happiness in a group of movements of which the New Thought and Christian Science may be mentioned as examples. These movements have passed the experimental stage and are proving potent means in preventing and curing disease and promoting personal peace and harmony. Again, health leagues, committees on national vitality, scientific studies in nutrition, the warfare against insects and a host of such movements are all working towards increased happiness and increased health. But now it is proposed to go still farther in promoting human welfare by the direct application of the laws of heredity to the improvement of the race. Eugenics is the name of this new science and its aim is to teach us to be not merely well nourished and well nurtured, but also well born. Eugenics is defined by Galton as the study of agencies under social control that may improve or impair the racial qualities of future generations either physically or mentally. In eugenics we see consciousness arriving at sufficient maturity to control race culture. The possibilities of this new science are unlimited.

The third direction in which intelligence is working to further the welfare of man is in social and political relations. Here the advances are too many and too rapid for any one to catalogue. One might recall such gains as the abolition of slavery, religious toleration, freedom of speech, freedom of the press, freedom of opportunity, the limitation or abandonment of the death penalty, the humanizing of prisons, the restriction of child labor, and the substitution of wise charity and helpfulness for injurious almsgiving. The rights of labor are now recognized and the whole laboring class more justly remunerated and accorded a position of dignity and respect. The rights of the workingman, his welfare and his comfort are secured by workingmen's unions, protective insurance, factory laws, eight-hour laws, pure food laws, free schools, free public libraries and many other agencies, while the general spirit of social progress and social improvement is shown by lend-a-hand movements, worth-while movements, Christian Endeavor societies, civic art clubs, the conservation movement, movements for the promotion of civic righteousness, of the square deal, and of universal peace, neighborhood and social centers, social surveys, social settlements, and kindred efforts having in view the greater happiness of all the people. In the event of famine, earthquakes or disasters of any kind in any part of the world, abundant charity cheerfully given and economically administered is immediately forthcoming. Finally, we are seeing the beginning of the custom of distributing colossal private fortunes in establishing and maintaining free public libraries, great educational and humanitarian institutions, and institutions for medical research and scientific investigations.

In particular there are four aspects of modern life and society which are distinctly optimistic. First, the elimination of fear. Second,

the advance in the position of woman. Third, the gradually lessening frequency of war and its possible abolition. Fourth, the agitation against alcohol.

So free are we from fear that we do not realize the bondage of men in former times to both supernatural and political tyranny. Virgil represents Æneas as pulling up a little bush and finding clots of blood clinging to the roots, whereupon his terror was so great that his hair stood on end and his voice stuck in his throat. Fear is the greatest source of human suffering. Until comparatively recent times nature has been something unknown and the unknown has been a source of constant terror. It is believed to be full of supernatural and possibly hostile agencies. Devils and demons and indignant deities, an angry and jealous God, possible future and retributive punishments, earthquakes and eclipses, all have contributed to make the life of man miserable. This burden of woe has now been lifted. Another view of nature prevails. Man has cast off fear and finds himself master of nature and perhaps of all her forces, while in religion the gospel of love is casting out the dread monster of fear. But it is not alone fear of supernatural agencies that we have escaped, but also fear of political tyranny and of sudden political upheavals connected with despotic governments and social instability. Few of us appreciate the profound security that we now enjoy, security of life, property and reputation.

The wonderful advance in the domestic and social position of woman and her corresponding happiness sounds a strong optimistic note in the present. In Queen Elizabeth's time a married woman and all her possessions almost belonged to her husband, very much as did his horse. He could take away her property or her wages or even pound her with a stick. Gradually she has secured the right to her own property, to her own earnings, and to her own children, and is now rapidly gaining the right to hold office, the right to an equal voice in public affairs and the right to equality of industrial opportunity. Woman's suffrage, for instance, partial or complete, is a fact in large portions of the United States, in New Zealand, New South Wales, South and West Australia, Finland, Norway, Sweden, and other countries.

Another ground of optimism is found in the decreasing frequency of war. The cruelty of war, the physical and mental suffering, and the immediate and remote social consequences, all together represent only a part of its ultimate evils. In his little book on "The Human Harvest," David Starr Jordan has shown how war in the past has operated to produce human degeneracy by removing the best and strongest men and leaving at home the sick and the maimed, the lazy and inefficient, the slaves and the commonest laborers to become the fathers of the next generation. Now the conditions are different. Even in the event of a war in this country, the conditions are such that no serious depopulation could happen and in Europe wars are already too far

apart to have this effect. It is true that only a too sanguine optimism can see the immediate abolition of war, but it is equally beyond dispute that there are now powerful forces at work in the direction of universal peace.

Still another optimistic factor of the present is the crusade against alcohol. This is a determined and persistent opposition and in the end will eliminate its use. Hitherto the opposition has been largely sentimental and has been directed not so much against alcohol as against drunkenness. Recent studies in the psychology and physiology of alcohol lead us to believe that it is a race poison. It is the most deadly form of the downward or recalcitrant action of matter. So far back as history goes it has acted as one of the most serious impeding forces to the upward progress of the human spirit. It is in spite of alcohol that progress has continued from century to century. It is impossible to estimate the damage it has done to the human race. Its elimination will be a far more difficult problem than the abolition of war. The psychological cause of the universal desire for alcohol lies deeper than has been supposed, and it is only when this cause is understood that successful headway will be made against it. But it is undoubtedly true that alcohol will have to go. The emergence of woman into political and social affairs will add new vigor to the opposition to it and psychological, physiological and sociological studies will solve the problem of method.

But, now, it may be said, while these optimistic views of life and society are most cheering and suggestive, still they are in a certain way superficial and particularly so as regards the economic outlook for the future. There are deep-lying causes at work, it may be said, which look towards human degeneracy rather than towards human uplift. Our present prosperity is due very largely, for one thing, to the fact that there have been ever to the westward rich unoccupied lands to relieve the congestion of our population and react as an invigorating influence upon our eastern civilizations. These lands are now nearly all occupied, and henceforth, remembering Malthus's doctrine of the increase of population and the law of diminishing returns in agriculture, we may look for trouble. In the United States, it may be said, our present flamboyant prosperity is due to the fact that we are reveling in the wasteful use of a by no means inexhaustible supply of bituminous and anthracite coal, petroleum, natural gas, timber and soil fertility. The end of all these rich supplies can not be far away. If we could perchance find a substitute for our coal and timber, yet there is no way of supplying the combined nitrogen necessary to renew our soil when the present sources are exhausted. Again, in other directions, it is said, the social forces put into operation by man are Lilliputian and a single convulsion of nature may overthrow them all. Take, for instance, our war against contagious diseases. When we have eliminated them, we have destroyed nature's social scavengers and she will take a

terrible revenge. In former days, tuberculosis, typhus, typhoid fever and smallpox swept through the land, removing crowds of the unfit and those not immune to these diseases, leaving the sound, the hearty, and the immune to become the fathers and mothers of the next generation.

Perhaps the clearest statement of these views is found in an article on "Decadence and Civilization," by W. C. D. and Catherine D. Whetham in a recent number of *The Hibbert Journal*. These writers point out that in all our sympathetic care for the unfit we are sacrificing heredity to environment. "It is conceivable," they say, for instance, "that a wilderness of sanatoria may serve as easily to increase tubercular disease in the future as to diminish it in the present." As regards our warfare against alcohol, they continue, we are only laying up for ourselves future trouble. The races of southern Europe, where wine is abundant, have gradually become immune to alcohol, those families not able to use it moderately having perished, so that drunkenness, while formerly common in these countries, is now rare. Hence it is urged that, if by restrictive measures we make alcohol unattainable for the present, in the future a demoralizing wave of alcoholism will overcome all barriers, showing again that we are sacrificing heredity to present environment.

Again, still further and still worse, it is said, the emergence of woman into industrial and political life, while it will purify and ennoble society for the present, means race deterioration in the future. Say the same writers:

> Apparently, for a time we can shift a great part of the burdens of the country on to women, who can undersell their husbands and brothers and we probably effect thereby a distinct temporary improvement in our own generation, for a woman of better education and character can always be secured for a lower rate of pay; but we are devouring our one essential form of life capital, female humanity and the process must end in disaster.

A man may be a hard worker in industrial or political fields and at the same time the father of a robust and numerous family. On the contrary; a woman's "essential function is motherhood," and participation in industrial or political activity invariably interferes with this function.

> It is not a mere coincidence that the women whose names are best known and most distinguished for social, artistic and literary services were for the most part unmarried or childless, so that the special gifts which brought them fame died with them.

So much, then, for the voice of the pessimist. We must admit that there is force in these arguments and that some of the dangers referred to are real dangers, but the spirit of the new optimism affirms that all these difficulties as they arise will be successfully met by the unconquerable power of the human mind, as others have been met before. There may be, it is true, no more rich unoccupied lands to the westward, but scientific agriculture is showing that there are almost infinite unoccupied possibilities in the soil under our feet. Malthus's law of popu-

lation is a mere bugbear and agricultural science is turning the law of diminishing returns into a law of increasing returns. As regards the exhaustion of our forests and mines and the impoverishment of our soil, the conservation movement is already here to protect them. Our forests may be renewed as they are in other countries and substitutes may be found for our coal which will be as superior to it as the electric light is superior to the old candle or lamp. Few will be sorry to see the passing of the coal with its dirt and its smoke. As regards the exhaustion of the combined nitrogen of our soils, science even now is learning how to imprison the free nitrogen of the air.

In an article by W J McGee in *Science,* October 6, 1911, on the "Prospective Population of the United States," we have a painstaking study of this subject, based on all kinds of data, including not only the observed decrease in human productivity, but also the relation of our natural resources to the increase of population. He finds the only real limitation of our natural resources to be in the water supply, and taking this fully into account, he estimates the population of the United States to be doubled in 1950, trebled in 1980, quadrupled in 2010, and so on to the year 2210, when we shall be supporting over eleven times our present population, or 1,017,000,000 people. His view is wholly optimistic, showing how movements already initiated are likely to overcome great apparent evils.

As regards the action of tuberculosis and other diseases of this class in purifying society by removing the unfit, it may be answered without hesitation that sanitary science can provide methods of purification far superior to these filthy diseases. An unsanitary medieval city might perhaps need dogs as scavengers. A well-kept modern city needs none such. So in regard to any possible racial deterioration as the result of the participation of mothers in industrial and political occupations, it is the business of society to consider just as much the conservation of human health and human vitality as the conservation of our forests and our soils. It is by no means impossible that society in the future will find means of preventing the production of the unfit and providing for the production of the best. The present movement in advancing the position of woman may go farther than equality of rights. It may give to the future mothers of the nation superior rights and superior privileges. The notion, however, that work and motherhood are incompatible has no foundation in experience. Small families and weak children are more often found among the idle and luxurious than among the workers.

The fact is that pessimism finds its explanation not in objective, but in subjective conditions. The psychological grounds of pessimism are not obscure. It springs usually from one of three sources. The first of these is lowered vitality. Optimism is the natural and necessary accompaniment of health. It flows from it as naturally as light from the sun. It is just the mental reflex of that normal physical activity

which belongs to the healthy body. Pessimism is the mental reflex of disturbed function, sometimes of the nerves, commonly of the liver or kidneys.

Then, secondly, pessimism comes in part from the over-seriousness and over-sensitiveness of the age, the incidental accompaniment of what we have called the adolescent stage in the development of human consciousness. The childhood of the race has past. We have become self-conscious, reflective, conscientious, a little careworn. The boyish, rollicking, happy-go-lucky abandon and exuberance of spirit exhibited in the writings of Shakespeare's times are absent now. In those days social conditions were relatively bad and comforts few, yet they did not care so much. They did not take life too seriously. They ate, drank, laughed, and died when their time came. Now we worry more. Writers like Tolstoi take life very seriously. Conditions in Russia are no doubt bad, but they are not worse than they have been and they are not sufficiently bad to fill a man's soul with such bottomless gloom as they did the soul of Tolstoi. His was an extreme case of the over-sensitiveness and over-conscientiousness of the age. He was unhappy because he had bread when others hungered, a condition which in former times has usually been the occasion of rejoicing. Our own sins and the sins of our legislators, our political leaders, and our masters of capital lie like an incubus on our spirits.

Thus we have already anticipated the third ground of pessimism. It is that we compare our present condition not with the past but with the ideal future, or rather with an ideal state which consciousness itself creates. Our physical condition, could it have been foreseen by Francis Bacon, would have seemed a veritable paradise. But we are not happy. Our workmen have better wages and fewer hardships than ever workmen had before, yet they are not satisfied. The New Atlantis is ever in the future. Thus, we come back to the position already indicated, that human consciousness is a wellspring of progress. It creates ideals and it is with these ideals that we compare our present attainments and pronounce them imperfect. This is what makes progress possible. It is the eternal unrest, the eternal aspiration of the human mind, which is never satisfied with the good, but urges us ever forward to something better.

We often hear reference made to "political unrest," as if it were some inherent social defect, a mere petulant, purposeless fault finding. But it is not a defect. It is the voice of progress proclaiming its discontent with the present and demanding improvement; not an idle but a rational discontent, recognizing the real evils of the times and perceiving more or less clearly the direction of the upward way. What, therefore, appears as pessimism is really the ground of the highest optimism. There is no static happiness, no happiness of mere content and satisfaction. What we require is growth, movement, struggle, aspiration, conquest.

WELFARE AND THE NEW ECONOMICS

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ECONOMIC thought is undergoing a profound and rapid transformation. Linked, as it must ever be, with the problems of government, economics has been drawn into the maelstrom of progressivism which has gripped the western world. Vainly do the classicists protest. Futility grips the throats of the doctrinaires. Economic science is being wrenched from its eighteenth-century setting and thrown bodily into the arena of twentieth-century discussion. How sound is this tendency? With what disquietude or satisfaction should men view the efforts of economists to take their places "on the firing line of progress"?

Society was ruled during the middle ages by arbitrary laws, enacted by the church, or by the state, acting (theoretically) for the church. The light of the semi-democratic civilization of Greece and Rome had faded from the political horizon. Despotism, the patron saint of the time, reigned supreme with fate, her next of kin.

Here and there a bold spirit arose, contending with authority, questioning theological dogma, and calling men to thought and freedom. Cells and gibbets harbored many such. Above them, the bulwarks of social tradition loomed stolidly, proclaiming abroad the noisome doctrine that, while a true believer might slay twenty Mohammedans in the name of Jesus, he might not think one original thought in the name of truth.

Yet the light broke. From questioning the infallibility of a corrupt and dissolute church, men turned to question the infallibility of the Scripture. They would at least read for themselves. So theological dogma was thrust aside here and there, by the braver hearts who began to ask of all things:

1. What is it?
2. Why is it?
3. How can we employ it for our advantage?

Similar questions had arisen in classical days, but the age of Scripture had overshadowed them. Now they were asked again, with redoubled vigor.

Gradually the answers were formulated. The first question resulted in classification, which is the foundation of constructive thought. The question "Why?" gave rise to evolutionary science. The world,

demanding fact as well as faith, was replacing theological dogma by scientific deduction.

Although it was freed from theological dogma, the progressive thought of the seventeenth and eighteen centuries was still dominated by the idea that laws of some kind were a human necessity. The social atmosphere still tingled with the spirit of past despotism. Hence, without a protest, men passed from the dominion of theological to the dominion of natural law. Even the ablest thinkers sought for principles which, like Newton's law of gravitation, would underlie and control all phenomena. The protest, "back to nature" was merely a demand that the world leap from the frying pan of theological absolution into the fire of nature-tyranny. Yet the thought of the eighteenth century teems with this demand. The Physiocrats voiced it; the natural theologians preached it; Rousseau popularized it. Its logical flower was the French Revolution, which was a blind effort to pour the new wine of emancipated thought into the old bottles of political pedantry. In the process much wine was lost. "Natural law" dogma bound the thought of eighteenth-century thinkers in exactly the same way that the "divine right" dogma had bound the thought of their ancestors.

Economics was born in the eighteenth century—born of natural theology and physiocratic philosophy. Hereditarily, economics suffered from inbreeding. Environmentally, it was hedged in by the narrowest of narrow concepts—that of subjection to "higher powers."

Was economics to become a science? Adam Smith and his contemporaries hoped that it was. How well marked, then, was the path! All sciences were founded on natural laws. If economics was to be raised into the hierarchy of sciences, a greater natural law must be found which would explain economic phenomena. The economists, therefore, applied the tests of science to their doctrines in order to establish their scientific nature. To the question, "What is it?" they replied, "A science of wealth." To the question, "Why is it?" they answered, "because of intelligent self-interst," "the law of supply and demand," "competition," and the like. The third question they did not ask because the eighteenth century accepted and obeyed nature's laws instead of trying to utilize them for human advantage.

Nevertheless, the third question must be answered. Of all things men will ultimately ask, "How can we employ these for our advantage?" The basis of the answer was laid in the sixteenth and seventeenth centuries, when free thought had largely escaped from theological dogma; when knowledge had ceased to be the right of the few and had become the privilege of all. In the eighteenth century the question was asked of the government. Men challenged the divine right of kings, and on both sides of the Atlantic democracy replaced monarchy.

During the nineteenth century experimental science asked the same question of natural law; established the power of human thought; forged the tools with which the work must be done; and bent immutable nature to the service of man through applied science. Thus knowledge, government and natural phenomena have been turned to human service. The twentieth century voices a demand that economics undergo the same process of transformation from a science which serves laws, to a science which serves society.

The claim of economics for conversion to social service is a double one. On the one hand, science has demonstrated that all so-called laws may be employed to serve men, or else, if their influence is harmful, counteracted and offset. Gravitation has ceased to be an enemy; the lightning holds few terrors; the waterfall is harnessed; the plague stayed; the desert blooms; time and space have lost their vastness; men have triumphed everywhere through the mastery of human thought. Whatever laws economics may depend upon are no more changeless than these overwhelmed laws of nature.

On the other hand, men have learned that the laws of economics differ from the laws of natural science in that the whole subject matter of economics is man made—the product of human activity. The laws of physics and chemistry are laws of a universe, which man had no part in creating. Economics, however, is the result of a man's creative energy, for man has made the economic world. Interest, wages, competition, monopoly, capital and private property are all the products of his ingenuity. The concept of law presupposes a law giver. Who gave the laws of the universe? We answer, God. Who made the laws of political economy? Man, because he constructed the economic system to which alone the laws of economics apply.

We are no more subject to the laws of economics than our ancestors were subject to the law of military tactics; than we are subject to the laws of education; or than our descendants will be subject to the laws of the sanitary science which we are creating. There are formulas of thought called "laws" in all sciences, but Napoleon overthrew and remade the laws of military tactics; Froebel restated the laws of education; and Pasteur created the science of sanitation. There is an economic law giver—man, who can unmake or remake that which he has made.

The laws of economics are in truth mere incidents in social evolution. Queen Elizabeth and her successors granted trade monopolies to favorites. The eighteenth-century economists enunciated the laws of competition and equal freedom as the great law of economics—the cure-all for economic woes, and lo, the Standard Oil Company, employing the law of competition as its most fearful weapon, has created a monopoly as complete as any ever granted by an absolute monarch. If we

lived under a barter economy, we should work out its laws. We broke away from the domestic system of industry when inventors made possible the factory system. The economic world is still in the making. Men are doing the work.

So long as men regard the laws of political economy as immutable, so long will they be in the grip of the powers which these laws express. It is in vain that Karl Marx argues regarding economic determinism; it is futile for Henry George to "seek the law which associates poverty with progress"; the future is hopeless so long as men believe that political economy is "as exact a science as geometry." Under the domination of economic law, the exploiter will continue to exploit, and the exploited to suffer. Not until men realize that they are the creators and arbiters of economic laws will economic laws subserve human welfare. The dawning lies beyond the fetish of economic determinism; the hope for the future rests upon man's ability to make of political economy an eclectic philosophy.

The economists in the past have asked "What?" and "Why?" of economic phenomena. The time has now come when they must face the third question and discover how economics may be made to serve mankind. Progress in other sciences has led plain men to question the validity of the fatalistic philosophy of Ricardo; the gloomy forebodings of Malthus; and the necessity for poverty, overwork, untimely death and the devastations wrought by the brutal hand of cut-throat competition. The discovery that opportunity largely shapes the life of the average man, determining whether he shall be happy or miserable, has led to an insistence that the economists part company with the ominous pictures of an overpopulated, starving world, prostrate before the throne of "competition," "psychic value," "individual initiative," "private property," or some other pseudo god, and tell men in simple, straightforward language how they may combine, reshape or overcome the laws and utilize them as a blessing instead of enduring them as a burden and a curse. The day has dawned when economists must explain that welfare must be put before wealth; that the iron law of wages may be shattered by a minimum-wage law; that universal overpopulation is being prevented by a universal restriction in the birth rate; that overwork, untimely death and a host of other economic maladjustments will disappear before an educated, legislating public opinion; and that combination and cooperation may be employed to silence forever the savage demands of unrestricted competition. In short, the economists, if they are to justify their existence, must provide a theory which will enable the average man, by cooperating with his fellows, to bear more easily the burden and heat of the day.

How shall this be? What relief may economics—"the dismal science"—afford? Perhaps the matter can best be stated in an analogy

suggested by Ruskin. Suppose that five men were to take a tract of a thousand acres for the purpose of running a general farm. Learned in the art of scientific agriculture, these men provide the necessary tools, equipment, fertilizers and seeds, prepare the ground, sow the crops, harvest the grain, potatoes, fruit and vegetables, and take them to market. Where they find their land too wet, they drain it; if, perchance, the tract is too dry, they irrigate; and if a test shows that a certain field needs lime, they promptly apply lime. These men are farming the land. They do not wait for the land to produce a living for them, but instead, they use the land in every conceivable way.

Suppose that, instead of fertilizing, irrigating and draining, these men upon discovering that one plot was very fertile, farmed only that plot, leaving the less fertile parts of the farm untilled; suppose that, when water stood in a field, they invoked the aid of physics and mathematics, ascertained that this field was low, and therefore bound to be wet; suppose that they abandoned a hill plot which would not raise tobacco without even attempting to ascertain whether it would grow buckwheat; suppose that after venturing timidly to try a few minor experiments, these men, discouraged and forlorn, should assemble around a stone, and, raising their hands to the sky, should beseech some higher power to make water run up-hill or tobacco grow on buckwheat land. Or, instead of praying, imagine their hopeless, hang-dog air as they gazed dejectedly over their thousand acres, exclaiming: "Alas, the law of gravitation makes our low land wet; tobacco will not grow on the highland; yonder field contains no lime for our clover crop; and even the cattle in the hill pasture suffer from lack of water."

What a picture! You sneer, contemptuously. "What sane man would talk so?" you demand. "The illustration approaches the ridiculous. Beseech a higher power? Bemoan the law of gravitation? Fiddlesticks! Irrigate, drain, lime, water, fertilize, and the land will bring forth in abundance."

True, true, but listen! Ninety million people, some of them intelligent men and women, living in one of the most fertile regions of the whole earth, possessed of boundless natural resources, of knowledge and of energy, have suffered for a century from devastating industrial depressions; have watched little children work their fingers raw in the coal breakers; have witnessed an exploitation of women that has required two hundred thousand of them to sell their bodies; have tolerated sodden misery, poverty, vice, criminality; have permitted one small group in the community to possess itself of the natural resources on which all depend, and to exact a monopoly price, from all, for the use of those resources; and now, after generations of this gruesome motion picture, these sane, strong men and women raise their hands to a higher power, or slink dejectedly into their caricature homes, making

scarcely an effort to throttle their taskmasters—hunger and emulation —or to stay the hand of the grim reaper who annually sends seven hundred thousand of them to premature graves.

Irrigate! Drain! Lime! Fertilize! Aye, farmer, do these things, and you will reap a plenteous harvest. You possess the knowledge and the tools—then bend enthusiastically to your task.

Educate! Legislate! Reorganize! Adjust! Aye, citizen, do these things and you will gain a satisfying livelihood. You possess the knowledge, the wealth, the tools—then bend enthusiastically to your task.

The time has passed when the man with the hoe, "bowed with the weight of centuries," "gazes on the ground," toiling that he may pay an eternal tribute to the feudal overlord. To-day he looks the future full in the face, and, with the faith of a freeman, applies natural science to the solution of the heretofore inscrutable agriculture problems. The time is coming when the man at the machine—striving, frantically hurrying through the long reaches of the ten-hour day—that he may obtain the wherewithal to buy for him and his bread, books, shoes and pleasure trips—servile to economic laws which he can neither understand nor master—will look the present system of industrial society full in the face, and with the faith of an emancipated soul will consign its laws to the devil and use the knowledge and the tools which the past has given him, to provide himself with the means whereby he may live.

Political economy is not a science founded on eternal principles, but a philosophy of livelihood. Its aim is not to astound us with its mathematical premises, or to frighten us with its threats of world disaster, but to outline a method by which men may raise the heavy yoke of traditional servitude and secure a more satisfactory living.

SCHOLARSHIP AND THE STATE

By Professor F. C. BROWN
THE STATE UNIVERSITY OF IOWA

FROM time to time articles appear from the press and more frequently still words are passed from person to person, which indicate that a great many citizens of our American states believe that scholarship exists only for the pleasure and profit of those who seek it. It is believed that this attitude arises more from lack of information and thought on the subject than it does from the general bad practises of those who proclaim scholarship. Consequently this paper shall purpose to set forth one simple, and it is believed irrefutable, argument for state support to scholarship.

The state may be regarded as an expression of the continuity of human life, and we may therefore postulate that it is its first duty to perpetuate itself. In spite of the fact that science shows that it is highly improbable that any state can live forever, it is nevertheless generally agreed that if the state so conducts itself as though it intended to live forever, it will live the longest and be the happiest while it does live.

Unfortunately there are many people who seem to think that the only duty of a state is to look after the welfare of the present generation. They somewhat seriously ask, "What has posterity ever done for us?" Perhaps we may compromise with these, for the sake of our discussion, on the basis that neither the present nor the future welfare of the community can exist independent of the other. In general there is a lack of far-sightedness among American citizens. H. G. Wells calls it, "state blindness." He says: "The typical American has no sense of the state." President Vincent, however, believes that the state is coming to stand for a common life which seeks to gain ever higher levels of efficiency, justice, happiness and solidarity. Ambassador Bryce, who seems to know us better than we know ourselves, declares:

> The state is not to them (Americans), as to Germans, or Frenchmen, and even some English thinkers, an ideal moral power charged with the duty of forming the characters and guiding the lives of its subjects.

I wish to present in this paper an ideal for the permanent and increasing betterment of the state and to suggest means for carrying out the ideal, for, as Arnold Toynbee once said:

> Enthusiasm can only be aroused by two things, first an ideal which takes the imagination by storm and second a definite intelligible plan for carrying the ideal into practise.

The future welfare of the state depends on economic and moral conditions. If the natural resources are used up and new resources are not discovered to supplant them, if the soil is worn out, the coal and other minerals are used up and wasted, the rivers are allowed to fill up, then organized human life will be almost impossible. On the other hand, if all the natural wealth were preserved and the coming generations should not be taught so as to appreciate proper moral standards, then obviously the natural wealth would be of no use.

The postulates naturally lead us to declare that it is the state's duty to investigate how it may best safeguard its future, and also to take what action best judgment may dictate. The first question that arises is whence is this best judgment to come. Plato's ideal state was to be provided with seers or wise men selected and trained according to the judgment of the wise men of the previous generation. But this idea is fundamentally at variance with the ideals and practises of our democracy. The people of the states of our time do not believe that any wise man, or any set of wise men, have the ability or the right to know beforehand what youths will when matured fully be best suited to direct the welfare of a single generation, much less the ability to select the future men of best judgment.

The idea is pretty well grounded in the American states, particularly in the west and the middle west, that the state should with all its power endeavor to see that every youth within its bounds should have equal opportunities to make the most with his native ability. No human power can distinguish a Lincoln before he has well matured. It is the privilege of the state, yes, it is even its duty, to see that every person shall do as much as possible, leaving it in a large measure to the individual to know what he should do. We must therefore admit that it is the duty of the state to offer educational assistance to all who will take it, and that this education must usually partake of two ideals which are apparently diametrically opposite. The ideal education will fit the individual to be proficient in some useful line of activity, and at the same time give him such a general education that he may be morally sound. The first is the element of the professional education and the second is the element of the liberal education. Excellence in the first requires, providing the number of individuals are properly distributed, essentially a narrow life, and gives a high efficiency with large immediate rewards both to the individual and to the state. Excellence in the latter gives a broad view of the functions of the individual and of the relative values of the various activities. So long as we maintain our democratic habits and insist on selecting our wise men fully developed from among the masses, the state should insist, as far as its wealth and its power will permit, that all the individuals should have a liberal education. No method of reasoning or no experience of the past can show

that the state can wisely permanently entrust the education of the individuals to any group of men or any group of interests. Logically this could only happen when the group interests become identical to the interests of the state.

The danger of permitting commercial interests to provide all education would be probably as great as the danger of extending that privilege to religious denominations. The commercial interests are not fearing a dearth in their supply of presidents and directors of their companies. These high offices can willingly be handed over to the friends and sons of the controlling millionaires. What they do want is trained labor. They want the stenographers who can give the greatest numbers of words for their money. They want draughtsmen who can give the most and best designs for a particular machine. They want in every case experts who can give the best judgment on a particular line of goods. It is of less than secondary interest to the factory owner, whether any of his employees can vote intelligently and conscientiously, or it may be stated more broadly that he little cares whether the men of his corporation are morally sound. Although it may seem a little inconsistent, he does want men who will not rob his cash register, or purposely endanger the owner's life. Consequently there are organized commercial interests at work in this country trying to get the universities to give the professional students a more narrow education than they now receive. They call it a more efficient education. They insist that it is scandalous that an engineering graduate is not worth more than twenty cents an hour to start, forgetting that the ideals and practises of society should be raised to a higher level by the work of the university. The late Mr. Crane recently, in criticizing the professional education of the University of Illinois, stated that the cost of training was out of all proportion to the product. He figured that the really successful electrical engineer cost the state upwards of $18,000. My reply is that the electrical engineering profession to-day stands as a monument to good investment of money and energy in pure and applied science, and this without calling especial attention to the betterment of society by the better class of engineers.

On the other hand, if the church controlled education, the training would perhaps be so idealistic that there might be considerable doubt if any of the practical needs of the professions would be met. A really successful electrical engineer would not be produced at any cost. Church education, naturally conservative, would be entirely inadequate for the needs of our changing democracy, even if it should try to eliminate creed. The conclusion is that even if the preachers, the doctors, the dentists, or the engineers would furnish all the money to educate their kind, the state can not afford to risk giving them this privilege.

The plea is that the state university, as the only fit organ of the

state, must first of all not merely consent to train men for the professions that serve the masses, but that it must demand this right. Of course we are assuming that the state is not a poverty-stricken one, and that it is not fighting for a bare existence. Secondly, the state's university must insist on giving its students a broad education. By this is meant that all students should not only be trained toward a professional career, but that they should also have the elements of a liberal education. They should by all means appreciate the value of scholarship in most lines of endeavor. President James says:

> I believe that the proper way to train a man or woman who is going to practise one of these learned professions, so far as a school can train him, is to prepare him for independent work in the sciences underlying his profession.

I understand that to mean that a graduate in electrical engineering should be prepared to carry on research work in physics.

And what is scholarship? It is the discovering of new knowledge and the proper dissemination of this knowledge. The discovery is the most important because it is the basis and the inspiration. There can be no permanent scholarship without research. I believe that it is more difficult to keep a semblance of scholarship alive without research, than it is to keep religion alive without spiritual leadership.

In how far is it wise to expect the state to foster research? To answer this question we may first inquire into the economic importance of investigation. A few years ago the members of the agricultural college of the University of Illinois went before the legislature and showed that they could make it possible to increase the yield of corn in Illinois by one bushel per acre, and that thereby they would repay all the money to run their college, if they did nothing else. This argument was so plain that the legislators could understand it and they gave practically all the money asked for. The money showed such good results in such a short time, that the engineering departments were then emboldened to lobby before the legislature, trying to show that money expended on research in engineering would be of great benefit to the state. They said that in ceramics they would investigate all the clays of the state to find building materials to replace the fast vanishing supplies of wood and iron. In mechanics they would investigate reinforced concrete so as to make it possible to construct buildings that would last for generations at a small cost. The legislature could understand this argument and so it gave bounteously to the engineering experiment station. The experiments in this station attracted attention over the whole world. The president then asked for an unheard-of lump sum of money for the graduate college in arts and sciences, merely to further knowledge in those subjects which were not of immediate value to the masses. This also was granted. The result of all this movement was that at the last legislature the University of Illinois was granted a sum of money in

excess of any one sum ever before in the history of the world by a single legislative enactment. This was in Lorimer's state and in Lorimer's time, strange as it might seem.

According to Dr. W. R. Whitney, in charge of the General Electric Company research laboratories, the advances in incandescent lighting alone in this country in the last ten years represent a saving of $240,000,000 a year or nearly a million dollars a day. He also calls attention to the fact that as a result of investigations with the mercury arc, his company has already had a sale of over a million dollars extra. There are a great many concerns in this country spending over a hundred thousand dollars annually on research. And why do they do it? Because it pays the company. Dr. Whitney believes that the advances of Germany over the other countries is largely traceable to their apparent overproduction of research men by well-fitted universities and technical schools. My argument is very simple. If an electrical concern that must at all odds pay dividends to the present generation, can afford to pay over a hundred thousand dollars annually for research, how much can the state afford to pay for research in pure science, in physics, in mathematics and chemistry, which will be absolutely essential to radical progress a century hence. The law governing the relation between visible radiation and temperature has been the guiding principle to most of the hundreds of thousands of dollars spent by present day commercial firms for more efficient lighting. New laws by the physicists of to-day will set new guiding principles for the millions of the future. The laws of induction as discovered in pure physics had to precede the most wonderful development in electrical engineering that this age or any age has witnessed in any line. My whole argument can be summed up here briefly as follows. Knowledge is the source of all power. If the state would get more power it must gain more knowledge. No wonder President E. J. James has been led to exclaim,

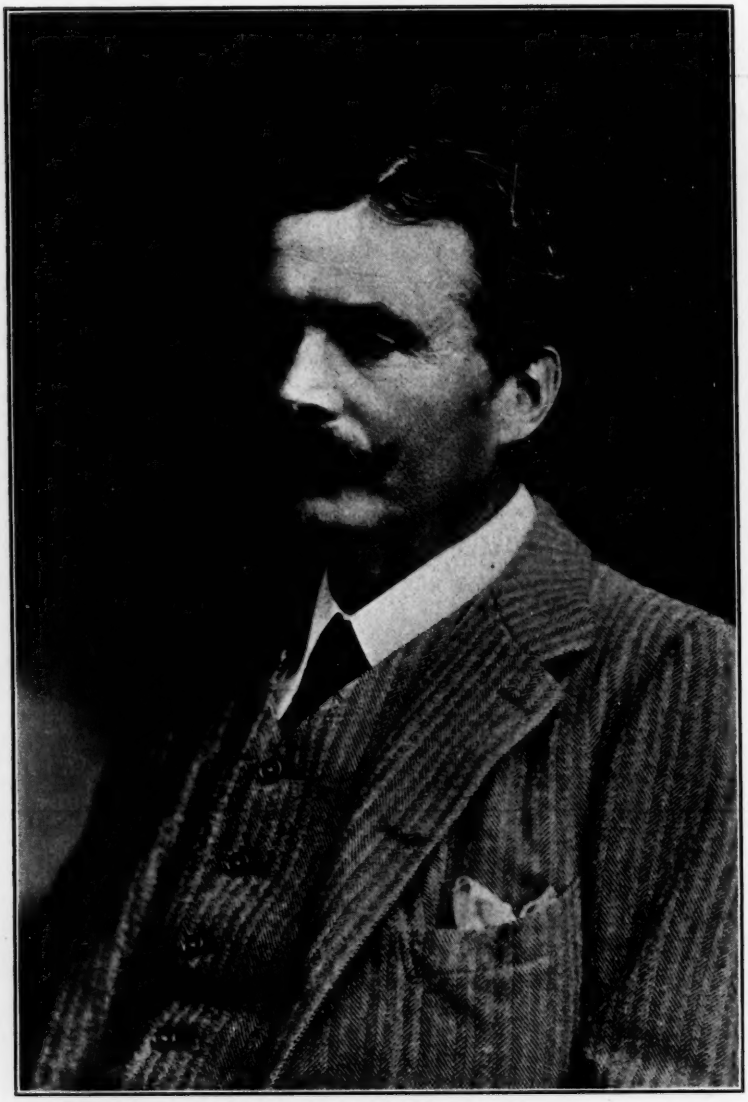
> Why, research is the life of the state university! It (research) is fundamental to it! Without that it could not be a university in any proper sense of the term. If its professors are not doing this, they are not qualified to give the training which we have in mind for the youth of the state who go there. So that research, investigation, is a fundamental quality of the state university, which is going to do for the people of the state the service which they have a right to expect.

Perhaps the moral status of the state is as important as food and shelter. I believe that the moral condition can be improved only by a further acquisition of the facts as to what promotes and what hinders well-being. Thus all knowledge improves moral conditions. The intelligent investigation of the results of alcoholic drinks is doing more toward driving out the drink habit than all the hatchets. The intelligent and unbiased investigation of the moral status of small towns

can not help but improve conditions. The man whose researches have shown him definitely what can be done to improve morals will always mark progress. The man who can point out just how the practise of the simple virtues of honesty and faith can better any particular conditions is certain to better social conditions.

It may be mentioned that all research in the right spirit has a moral value, which, however, it is difficult to evaluate in simple units. Any man who is striving to extend the bounds of human knowledge is thus far a source of inspiration to all who know him, and a lesson in faith and hope to those who know of him. Particularly in a university the teachings of a man of research are those that are most likely to inspire the spirit of wonder and high ideals among the students. It has hardly been the province of this paper to point out how the installation of the proper ideals, free from tawdry sentiment, among university students, permeates the whole society of the state.

Why must not a state entrust the seeking after knowledge to institutions outside the state? One university professor once said that it was useless for a state to try to build up a respectable graduate school near Chicago University. The inference was that the state could well let Mr. Rockefeller's millions seek after new knowledge and then help itself. Of course it might, but this attitude when looked into carefully is ridiculous. It is just as bad as for a citizen to depend on his generous neighbor's parlors to entertain his company. If a state would be a parasite and depend upon forces outside itself to develop new knowledge, then by the laws of nature it must take the chances of a parasite. But I believe that with a healthy, wealthy and vigorous body of people, state pride will forever demand that the state shall do its share toward productive scholarship.



ADAM SEDGWICK,

late professor of zoology at Cambridge and London, by whose death at the age of fifty-seven years science has suffered a serious loss.

THE PROGRESS OF SCIENCE

THE NUMBER OF SCIENTIFIC MEN IN THE WORLD

THE second edition of the international "Who's Who in Science" (edited by H. H. Stephenson, London, 1913) gives a classified index, from which can be counted up the number of scientific men in different countries and in different sciences. The compilation favors Great Britain in the first instance and the United States in the second, and is not very critical. It gives, however, some idea of the relative numbers of scientific men in other than English-speaking countries. The United States is given first place in the possession of scientific men of the degree of distinction proposed for admission to the book, the figures for leading nations being as follows: United States, 1,678; Great Britain, 1,472; German Empire, 1,280; France, 423; Austria-Hungary, 348; Italy, 215; Switzerland, 214; Holland, 155; Canada, 146; Sweden, 109; Russia, 97; Denmark, 93; Belgium, 90; Norway, 88. The German Empire has thus about three times as many scientific men as France, which nation is now but little superior to Austria-Hungary, or the three Scandinavian nations. Italy and Switzerland have each about one half as many scientific men as France. Sweden, Russia, Denmark, Belgium and Norway have each about a quarter as many.

About one half of our scientific men hold the doctorate of philosophy from American universities and about three fourths of those receiving this degree continue to do scientific work. According to the compilation printed annually in *Science*, the average number of degrees conferred in the natural and exact sciences from 1898 to 1907 was 124; from 1908 to 1912 it increased to 212. As the number of scientific men added each year is about 50 per cent. above those who receive this degree, the total number added to the ranks of scientific men in this country during the past fifteen years would be about 3,500. The number of degrees of doctor of philosophy given in the sciences by the 21 German universities to Germans in 1909–10 was 564, which probably about represents the increase in the number of scientific men. It follows that at present we are producing about half as many scientific men as Germany; twenty years ago it was in the neighborhood of one fourth as many.

If we make the assumption that the numbers of scientific men entered in the international "Who's Who in Science" for the continental nations should be increased fourfold to correspond with the entries for the United States and the United Kingdom and that there are 6,000 scientific men in the United States, the numbers for the different nations would be approximately: Germany, 18,000; France, 6,000; United States, 6,000; Great Britain, 5,000; Austria, 5,000; Italy, 3,000; Switzerland, 3,000; Holland, 2,000; Sweden, Russia, Denmark, Belgium and Norway, 1,500; Canada, Spain, Portugal, 500; Bulgaria, Roumania, 150; Servia, Greece, 25. For the other continents the figures would be roughly: Asia, 2,000; Central and South America, 500; Australia, 500; Africa, 300. The number of men now living who have made contributions to the advancement of science is consequently in the neighborhood of 60,000, of whom about one tenth live in the United States. The number of scientific men per million population in 1860 (the approximate average date of their birth) would be for the several countries: Switzerland, 1,200;

Denmark, 938; Norway, 938; Holland, 606; Germany, 472; Sweden, 395; Belgium, 320; United States, 191; Great Britain and Ireland, 172; France, 163; Italy, 120; Austria-Hungary, 73; Russia, 22. The number for Massachusetts is 654, placing that state above Holland. As De Candolle has shown, the supremacy of Switzerland has been maintained for 200 years. He gives political and social causes which he holds would account for it. These also apply in large measure to Denmark, Norway and Holland.

THE SCIENTIFIC CAREER IN THE UNITED STATES

THE number of scientific men of distinction would tend to be in proportion to the total number of scientific men a generation ago rather than at present, and the United States can not expect to have nearly one tenth of the eminent scientific men of the world. Professor Pickering found (THE POPULAR SCIENCE MONTHLY, October, 1908, and January, 1909) that of the 87 scientific men who were members of at least two foreign academies, six were Americans, as compared with 17 from Prussia, 13 from England and 12 from France. In so far as our scientific production is so measured, the reference is to a generation ago when our universities were only beginning to develop and research work was only beginning to be appreciated. It is a striking fact that of the six distinguished Americans, three are astronomers; and astronomy is the only science in which thirty years ago the facilities for research work in this country were equal to those of the leading European nations. Of the remaining three, two have not been engaged in teaching, and the third has been practically freed from teaching for his research work.

It is not possible for men to earn their livings by scientific research. Like other work for the benefit of society as a whole, and unlike business or professional service which can be sold to individuals, it must be rewarded by society. In the past reputation, social recognition, titles, prizes degrees, membership in academies and the like have been used as rewards, but these form a fiat currency which is now debased and scarcely passes in this country. It presupposes that the scientific man has independent means of support, and the group from which he can come is comparatively small. The method has succeeded in Great Britain, but in our democracy we can not afford to keep a leisure class for certain desirable bye-products. It is in every way better and cheaper to pay for our science. Germany owes its leadership in the nineteenth century to the provision of highly regarded university chairs given as a reward and as opportunity for research.

Such opportunity for scientific research as exists in the United States is also chiefly due to the universities. Of our thousand leading scientific men, three fourths earn their livings by teaching, nearly all in a few universities. These institutions deserve credit for what has been accomplished and responsibility for the fact that we have failed to equal Germany, England and France in the production of scientific men of high quality. There are many positions and many scientific men, many students and many executive officers. But our colleges and professional schools are not of university grade, our graduate students are not the men of exceptional ability selected from the whole people, but, as a group, men preparing to follow a safe and humble career; safe, so long as no offence is given; humble, unless it leads to an administrative position. The professor is subjected to official routine and executive machinery; his salary, at best but meager, his work and even his position are dependent on the will of a superior official. We may hope that this is only a temporary phase in university development, corresponding to similar conditions in poli-

A WATER-HEN RISING TO THE SURFACE.

A SEAL PLUNGING UNDER WATER.

Photographs of animals under water taken by Dr. Francis Ward and reproduced from a series in the *Illustrated London News*.

ties, business and society, not unnatural under rapid material exploitation in the childhood of a democracy. The danger is that great men may be lacking in our universities when the time comes for them to assume the place they should hold in the community.

Of our thousand leading scientific men, 739 are in educational institutions, 110 in government work, 59 in applied science, 38 in museums and gardens, 36 in research institutions, 18 are amateurs or in other professions. The conditions in the government service are somewhat similar to those in the universities. There are men and money in abundance, but mediocrity is favored rather than genius. In the establishment of endowed research institutions the United States has taken a forward step which may give to us the world's leadership in scientific research. In our research establishments, in our universities, in government, state and municipal service, in discovery through the application of science, we have possibilities never before presented to any nation. It will be well for us and for the world if these are realized in performance.

SCIENTIFIC ITEMS

WE regret to record the deaths of Professor Robert Woodworth Prentiss, who had held the chair of mathematics and astronomy in Rutgers College since 1891; of Dr. George McClellan, a Philadelphia surgeon, known for his researches in anatomy, and of Dr. Adolf Slaby, professor of electrotechnics in the Berlin Technical School and the University of Berlin, known for his work in wireless telegraphy.

IT is announced that Dr. H. B. Fine, professor of mathematics in Princeton University, has been offered by President Wilson the ambassadorship to Germany.—Dr. David F. Houston, secretary of agriculture, will retain the chancellorship of Washington University on leave of absence.—Professor Willis Luther Moore, who has been chief of the United States Weather Bureau since 1895, has been retired from this office.

THE Bruce medal of the Astronomical Society of the Pacific has been awarded to Professor J. C. Kapteyn, of Groningen, for his work on the proper motions of the stars.—The Harris lecture committee of Northwestern University has announced that the Norman Waite Harris lectures for 1913–14 will be delivered by Dr. Edwin Grant Conklin, professor of zoology at Princeton University. The general subject of his lectures will be heredity and eugenics.

THE university faculty of Cornell University passed on March 14 the following resolution:

WHEREAS: Professor Willard C. Fisher, a distinguished alumnus and former fellow of the university, has been dismissed from the chair of economics and social science at Wesleyan University on grounds stated in the letters of January 27, 1913, exchanged between the president of Wesleyan University and Professor Fisher; therefore,

Resolved, That the faculty of Cornell University extend to Professor Fisher greetings and assurance of regard, with the message that his *alma mater* still seeks to maintain and extend the spirit of liberality, toleration and loyalty to truth, illustrated by the principles and lives of its founders, Ezra Cornell and Andrew D. White.